June/July, 1978
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The Third World's Energy Crisis

Multiplying Energy With Heat Pumps

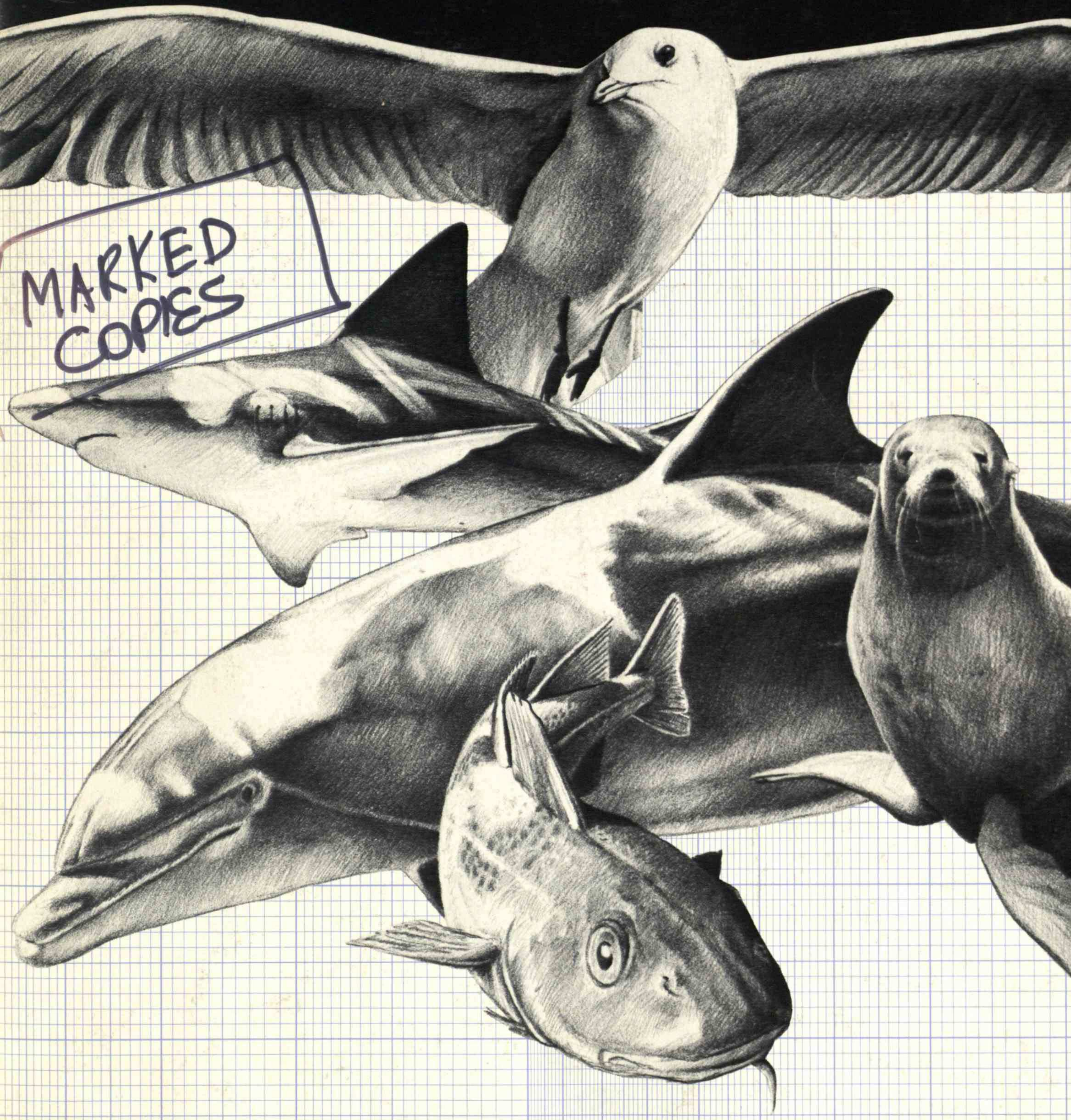
How Corporate Style Sets Innovation

The Big Powers of Large Lasers

Monitoring Free-Ranging Animals

Technology Review

Edited at the Massachusetts Institute of Technology



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"It's pretty spooky rowing around inside a supertanker in a rubber boat."

"That's me in the back of the rubber boat," says Chief Mate George McShea. "We're not rowing on oil, but on a saltwater lake in the belly of a supertanker. And it's one aspect of life on a supertanker I can't get used to.

"Sure, a supertanker is three football fields long, and twelve stories high. But after a while those are just numbers.

A lake in a cave

"This tank inspection is something else. After the tanks are cleaned and the residual oil retrieved and stored, they're flooded with seawater, and inspection crews go inside, checking structural integrity.

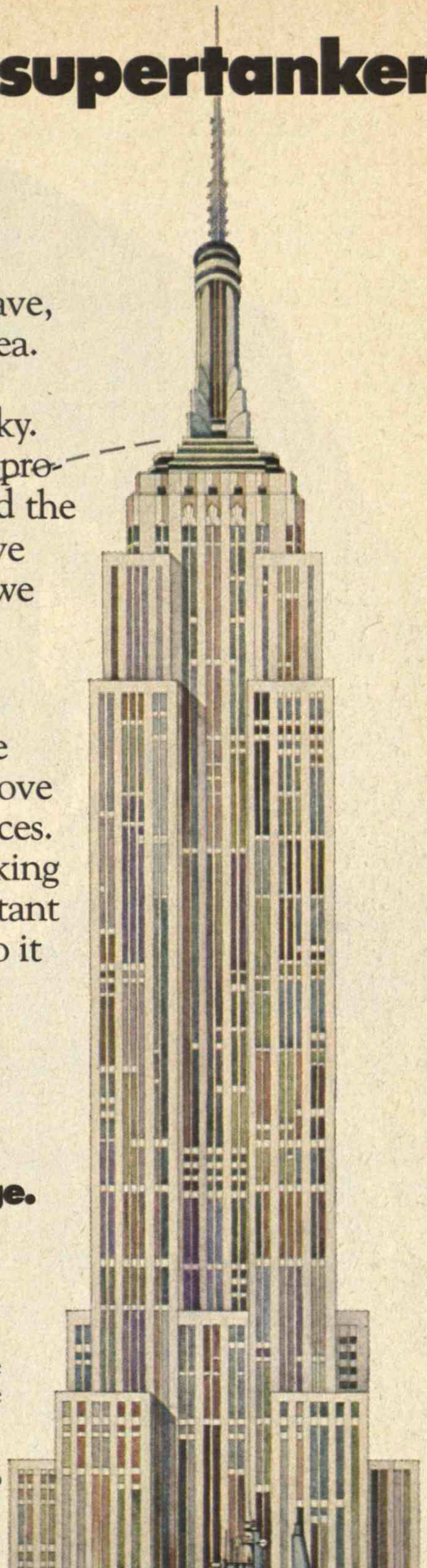
"It's like a lake in a cave, but it's inside a ship at sea. It's a big job, and sometimes it gets pretty spooky. But it has to be done, to protect the ship, the oil and the ocean. Gulf tankers have a fine record; we do all we can to keep it that way.

Most efficient

"Supertankers are the most efficient way to move so much oil such distances. It's a real challenge working on them. But it's important work, and I think we do it well."

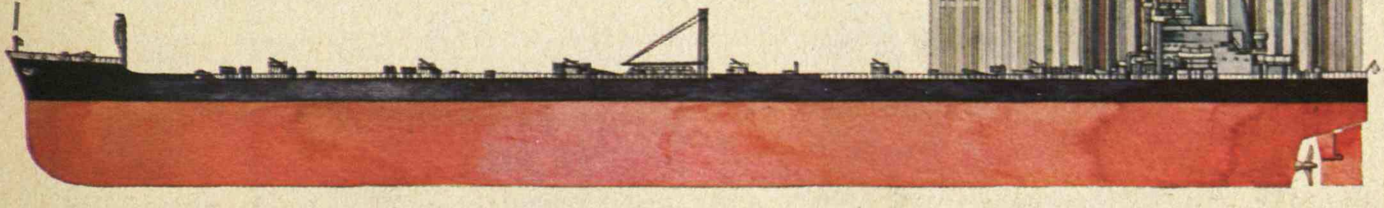
Gulf

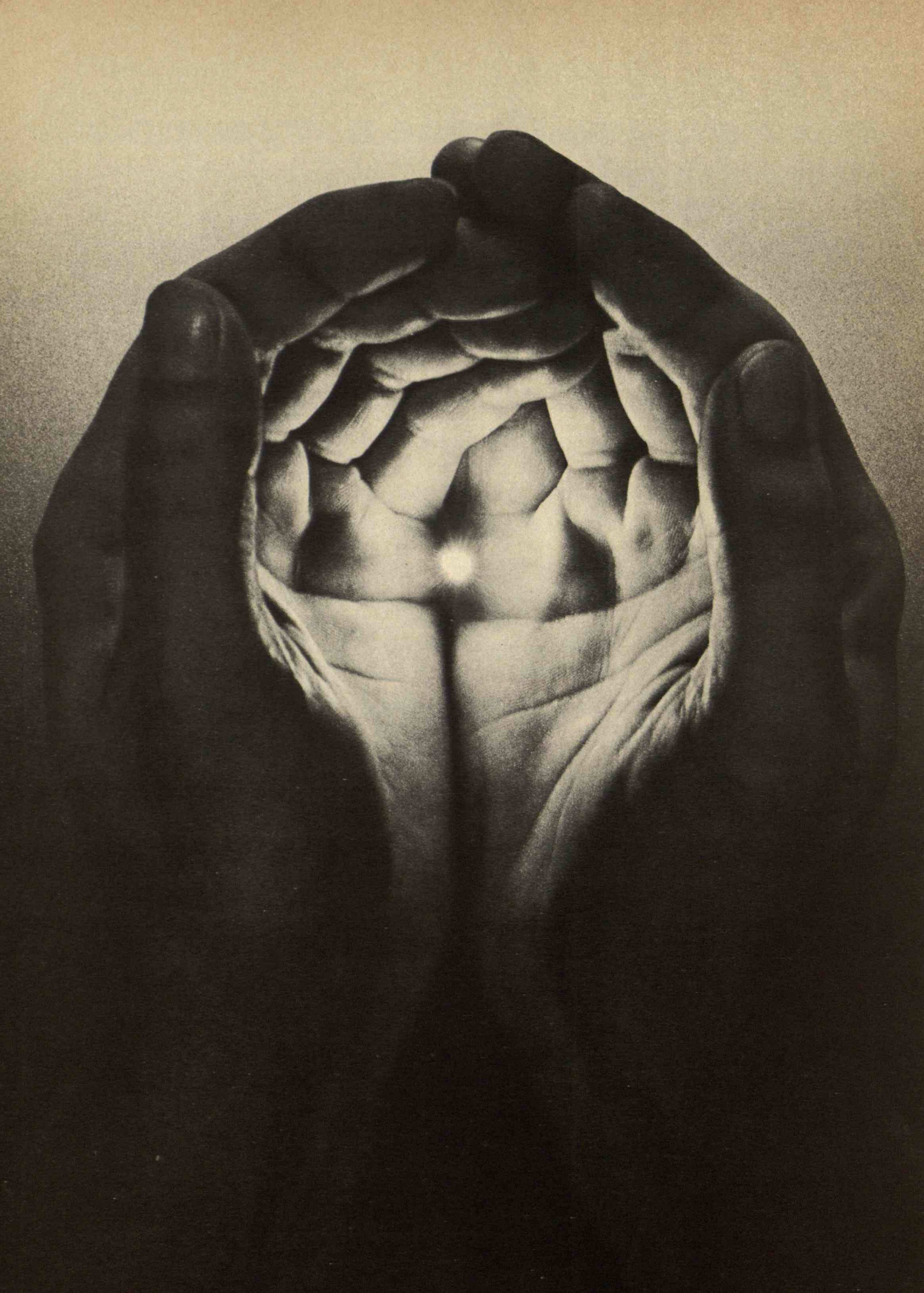
Gulf people: meeting the challenge.



Supertankers—some almost as long as the Empire State Building is tall—are the most efficient way to ship so much oil such great distances.

Gulf Oil Corporation





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Innovations like this are the result of close collaboration between Western Electric, Bell Labs and your local Bell telephone company.

Working together to keep your phone system the best in the world.

Western Electric

Edited at the Massachusetts Institute of Technology

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Technology Review

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Articles

Monitoring Free-Ranging Animals 32
John W. Kanwisher

A marine physiologist with an engineering eye discovers the brain waves of a shark, the fear response of a cod, and the energy efficiency of a hummingbird.

Patterns of Industrial Innovation 40
William J. Abernathy and James M. Utterback

The definition — and focus — of innovation changes as a company matures. A product innovation by a small, technology-based company is often the same process equipment adopted by a large company to improve production.

Energy for the Third World 48
William F. Martin and Frank J. Pinto

Over 100 nations now wait at the borders of rapid economic growth. But they'll need a good portion of the world's diminishing energy resources to take that next step.

High-Power Lasers 57
James P. Reilly

High-power, continuous-output lasers are now used in industry for tasks from heat-treating automobile camshafts to ship welding. In the offing are uses for isotopic separation of uranium, and perhaps ultimately for the propulsion of spacecraft.

Heat Pumps: Off and Running . . . Again 64
Leon R. Glicksman

Are you rejuggling your budget just to cover rising heating costs? A better idea might be heat pumps — a technology that appears to defy the law of energy conservation by producing thermal output two to three times greater than its mechanical input.

Departments

Cover
Illustration: John Whalley
Design: Nancy C. Pokross

First Line 6

Letters 6

The Nation: David F. Salisbury 8
How to capture an alternative energy: sprinkle salt on its tail. Scientists propose to use salt and water to harness osmotic energy.

Environment: Ian C. T. Nisbet 10
Toxic chemical pollutants are still seeping through the net of the Federal Water Pollution Control Act.

Technology and Science: Robert C. Cowen 12
The internal struggle for federal funding may send some scientific laurels overseas.

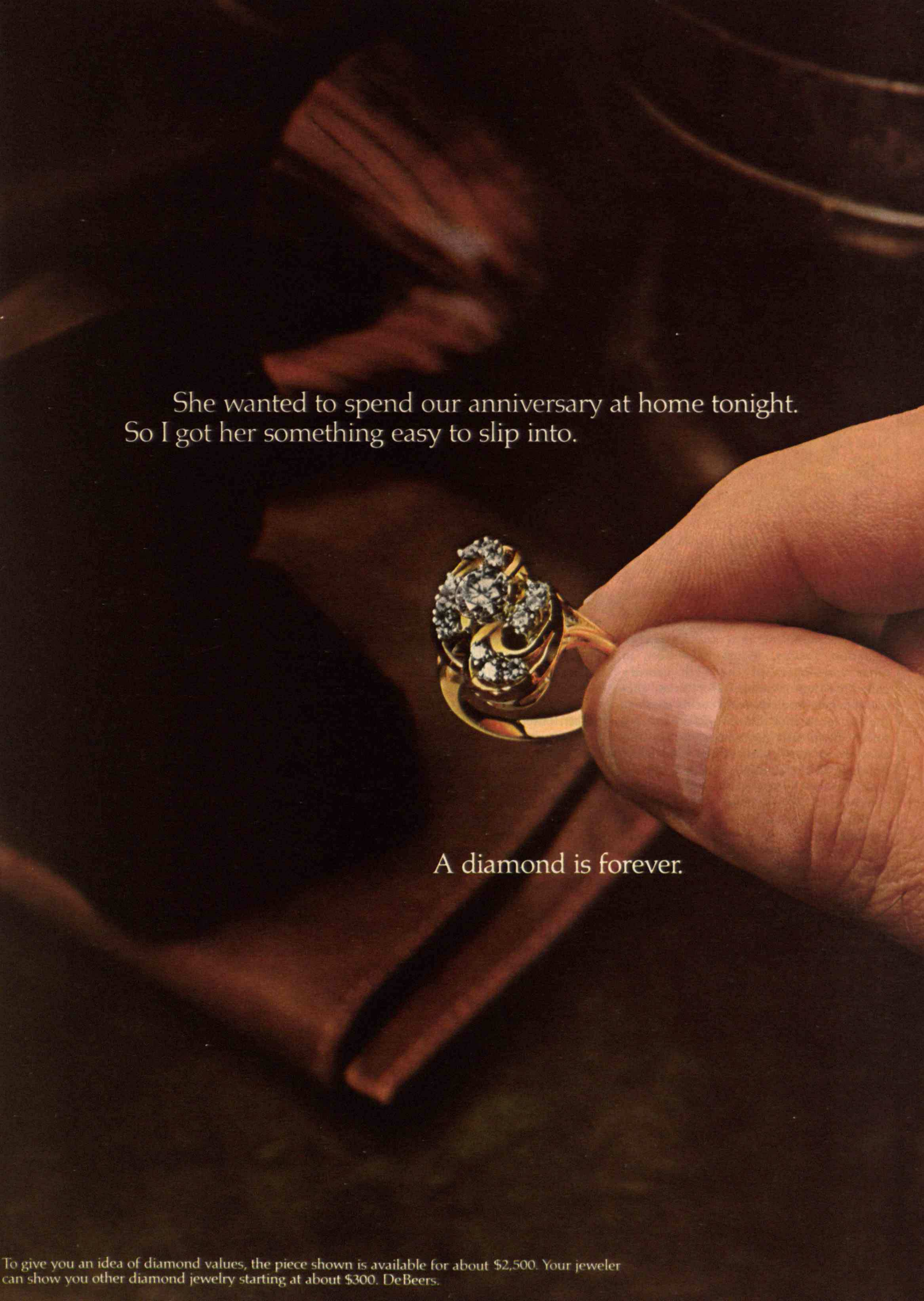
Books and Comment 14
Airport Systems Planning, reviewed by Jonathan Schlefer, **14**

Energy Demand Studies: Major Consuming Countries, and *Energy Supply/Demand Integrations to the Year 2000*, reviewed by Lee Schipper, **15**

Trend of Affairs 20
Transportation, **20**
Aerospace, **22**
Energy, **24**

Puzzle Corner: Allan J. Gottlieb 26
Adventures on a leisurely trip from aardvark to zymurgy.

M.I.T. Reporter 29
A digest of news from M.I.T.


She wanted to spend our anniversary at home tonight.
So I got her something easy to slip into.
A diamond is forever.
To give you an idea of diamond values, the piece shown is available for about $2,500. Your jeweler can show you other diamond jewelry starting at about $300. DeBeers.

First Line

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"Woe to the People of Egypt When (a) Comet Appears in Gemini"

Fifty years ago the astronomer Edwin P. Hubble made it clear that the Chinese had in fact observed and recorded in 1054 A.D. the supernova whose remnants we now see as the Crab Nebula. Chinese accounts describe a new star brighter than Venus, visible in full daylight for 23 days and in the night sky for perhaps six months. Curious, then, that no references to such a remarkable discontinuity in the heavens can be found in European or Arabic records of the time.

Until now.

Intrigued by our December issue of which Kenneth Brecher was Guest Editor, Elinor and Alfred E. Lieber of Jerusalem called Professor Brecher's attention to what all three now believe is an eyewitness account of the supernova as seen in the Near East. They find in the observations of one Ibn Butlan, a Christian physician from Bagdad then in Constantinople: "One of the well-known epidemics of our own time is that which occurred when the spectacular star appeared in Gemini in the year 446 H. (April 12, 1054, to April 1, 1055) . . . Thus Ptolemy's prediction came true: 'Woe to the people of Egypt when one of the comets appears threateningly in Gemini!' "

Calculations show that the supernova, whose remnants we now see in the constellation Taurus, would have been in what astrologers of the 11th century called the sign of Gemini. Ibn Butlan's account when studied in full seems to place the appearance of this *athari kawkab* between April and September, 1054, and possibly in the season of the Nile River flooding, in the summer, which is consistent with the Chinese record of its first appearance on July 4, 1054.

In the British journal *Nature,* Professor Brecher and Mr. and Ms. Lieber write their answer to "the question which has puzzled astronomers ever since Hubble first made the connection between the 1054 event and the Crab Nebula: Why did no observer in Europe or the Islamic world see and report the explosion?

"The answer is, one did." — *J.M.* □

Letters

The Moons of Mars

I enjoyed the December issue on Ancient Astronomy very much. I would like to add a note on "lucky guesses" to Professor Brecher's article, "Sirius Enigmas," in which he discusses the famous moons of Mars mentioned by Jonathan Swift in *Gulliver's Travels.* The idea of two moons seems definitely to follow from Kepler's numerology, but I have not seen anyone address the origin of the specific numbers for the orbital parameters.

Swift used orbital radii of three and five planetary diameters, and periods of ten and 21.5 hours, while the real values are 1.4 and 3.5 diameters and 7.6 and 30.3 hours (planetary diameters being the natural unit since that is what is observed directly in the telescope). If Swift were looking for reasonable numbers to use, he might have looked up the values for these prototype planetary satellites, the Galilean moons of Jupiter (from which Kepler got his numerical progression for the number of moons). The values for the first two, Io and Europa, are 3.0 and 4.8 diameters, and 42.5 and 85.2 hours. Looking for simple numbers to facilitate the arithmetic of Kepler's Third Law, Swift would have chosen 3 and 5 diameters. He could not borrow the periods, too, since that would be too obvious, and he probably realized that the relationship between radius and period was different for different planets.

To figure out periods which agreed with the Third Law, he would find the ratio of the cubes of the radii and extract the square root, which gives the ratio of periods equal to 2.1517. The first three significant figures give a satisfyingly close fit. The periods themselves should be on the order of tens of hours to be similar to Jupiter, and the simplest ratio is the one given by the decimal system itself: 21.5 to 10. One could round this to integers by doubling (43 to 20), but the fraction adds an air of versimilitude: all integers would be too neat. In addition, Swift may have noticed that periods were measured more accurately than radii, since the former can be averaged over a long time.

The good agreement with reality may be attributed to the fact that most satellites are spaced in the range of a few diameters, which is presumably related to their method of formation. Applying such simple spacing ideas was hardly unscientific for Swift's time: 50 years after *Gulliver's Travels* (it was written in the 1720s, not the 1750s) Bode promulgated his Law of planetary spacing, which perhaps led to the discovery of Uranus a few years later. By the way, had Swift known of Amalthea, the true innermost moon of Jupiter discovered in 1892, and had he used it and Io as his model for Mars, the agreement would have been frightening: 1.3 and 3.0 diameters, and 11.9 and 42.5 hours.

In short, as people investigating the fringes of science know, lucky guesses may not have to be all that lucky to look good. What is perhaps most interesting today in the Swift episode is the fact that an author could write a major novel in which non-trivial quantitative science such as Kepler's Third Law would be so casually included (it would be interesting to know how many of his readers checked his arithmetic). We've come a long way in terms of "science appreciation" to reach today's Two Cultures.

Stephen Donnelly
Woburn, Mass.

Professor Brecher comments:

The origin of Swift's remarkably accurate predictions of the existence and periodicities of the Moons of Mars 150 years before their actual discovery has been discussed many times, most recently, I believe, by Owen Gingerich, one of the contributors to the December issue. In an article in the *Journal for the History of Astronomy* entitled "The Satellites of Mars: Prediction and Discovery" (1970, pp. 109-115) he also offers the Io-Europa orbital radii as the origin of the relative orbital periods of Phobos and Deimos. However, he wrote that ". . . we can only suppose that ten hours (as the period for Phobos) was chosen for convenience."

I should add here that the story of the Moons of Mars is not all good luck. In 1945 a secular acceleration was noted in the periods of Phobos and Deimos. Calculations suggested that the amount was too large to be caused by Mars' atmospheric drag or other effects unless the densities of the moons were very low. In 1959, the immensely imaginative Russian astrophysicist Joseph I. Shklovskii suggested that these satellites might be artificial. This provocative suggestion survived the succeeding decade, but not the recent Viking Missions which showed the Moons to be the mottled, baked-potato-like, very natural rocks that they are.

The Odds of Weather

"It's just like playing dice," Dr. Mitchell said. "After a run of sevens (milder weather), the probabilities favor other faces (more extreme weather), and another string of sevens is unlikely."

I'll give odds that Robert Cowen in his May column *("Weather: No Picnic for Forecasters," pp. 7-8)* never checked with Allan Gottlieb, or anybody from M.I.T.'s Mathematics Department.

"After a run of sevens" the probabilities of other faces turning up are not *favored;* they are exactly the same as they always were, regardless of past events. And "another string of sevens" is no less likely (or more likely) based on what was rolled before. (At least that was what I was taught at M.I.T. back in 1938.)

E. Scott Pattison
Dunedin, Fla.

Hard Data on Soft Energy

"Solar Economics Comes Home" by Mark Hyman, Jr. *(February, 1978, pp. 28-35)* is a contribution to the growing interest in home solar heating. The data were especially valuable as it is very difficult to find hard data on home systems. Most often these are replaced by promises of "payback in several years." However, even Hyman's cost data leave a little to be desired. He says that "for about $3,000 one could install a solar domestic hot water heater . . . (which) would heat as much water annually as about $300 worth of electricity. . . . (The) installation

would pay for itself in about ten years." That ten-year payback would occur only if money were loaned free and if the concepts of "present worth" which we teach in engineering economy courses were not applicable. Current FHA interest is 8.75 per cent. An initial investment of $3,000 with an annual payment of $300 at this interest rate would require 25 years for payback, not ten.

If Mr. Hyman made this same assumption of free money when he described his own system (payback in about 30 years given fuel savings of $729 per year), then his system cost about $22,000. He could never pay that back at any interest above 3.3 per cent without a loss. Further, if his total system with 1,200 sq. ft. of collector did cost $22,000, that amounts to $18.33 per sq. ft. of collector. The November, 1977 issue of *Solar Engineering* (pp. 10-11) listed solar hot water installations on hotels and motels nationwide. While these systems were hot water heating only, they were of comparable size. The average system cost per sq. ft. of collector of this list is about $42.00, over twice Mr. Hyman's cost. Is it possible that Mr. Hyman did much of his own work and most of his own design and engineering? If so, that cost must be estimated and included in system cost.

I believe it is crucial that the proponents of solar energy (I count myself as one) be scrupulous about system life-cycle-costs. There is no question that our society will go to solar energy in whole or in part, but when we do, we shall pay *much* more for energy than we do now. The public must understand this. In the 1950s, the proponents of nuclear energy (I again count myself as one) spoke of plentiful energy so cheap that it would not have to be metered. It may be that the public has reacted badly to that broken promise.

Charles J. Bridgman
Dayton, Ohio

Mr. Bridgman is Professor of Nuclear Engineering at the Air Force Institute of Technology. — Ed.

The Mark Hyman, Jr. contribution to the February issue was refreshing indeed — very little reliable data are available on the *actual* performance of solar systems.

But his use of electric resistance backup could not be tolerated on anything but a token scale. If many dwellings used solar systems assisted by electric, the load bias on the utility would be unmanageable. Even off-peak storage of electric energy would make sense for only a small fraction of the total space heating load.

Both solar energy and public utility electricity are capital intensive schemes — to use one as a backup for the other is like navigating the Charles River in the Queen Mary, towing a second Queen Mary as a lifeboat.

Richard C. Hill
Orono, Maine

Mr. Hyman responds:
In my article on solar home heating I attempted to achieve a balanced ("neutral"?) viewpoint. Against my enthusiasm for the field, coupled with my belief that we are poised on the edge of energy disaster, I must pit the undoubted high capital cost of solar heating and the general lack of public interest in making present sacrifices for future energy.

In reply to Professor Bridgman, the vernacular in the solar field for "payback" time is usually interpreted as the capital investment divided by the annual savings. As regards solar installation costs, no one is making much money in the field unless he is involved in some government-backed contract — and not always then! A low but reasonable estimate for a large-scale solar installation is $20 per sq. ft. of collector. For smaller installations, this rate rises. For example, I have recently made an engineering estimate of $2,600 for a 67 sq. ft. system and $3,400 for a 111 sq. ft. system.

Mr. Hill felt that I should not have used electricity as a backup. For a less solar-intensive house than mine he would be right — up to a point! For a more economically practical approach to solar heating,

Continued on p. 18

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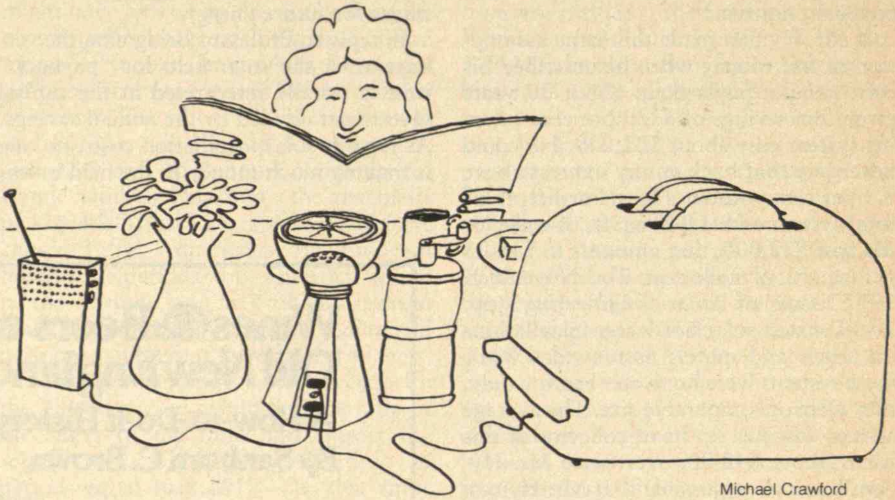
Plugging Into Salt

David F. Salisbury, who reports on science for the Christian Science Monitor *from its West Coast Bureau, is a regular contributor to the* Review. *He studied physics at the University of Washington (B.S. 1969).*



Michael Crawford

A new use found for common table salt teaches a valuable lesson: energy is all around us; we just need ingenuity to put it to work. Few people — even among the experts — realize that the abundant white crystals of salt are an untapped source of solar energy.

The energy potential in salt comes not from combustion, as in the case of petroleum, nor gravity, as in the case of hydroelectric power, but from a more subtle law of nature: osmosis.

Osmosis is the tendency of a solvent, such as water, to diffuse through a permeable membrane from a dilute solution to a more concentrated one in order to equalize the two concentrations. This process is fundamental to cells which must maintain high concentrations of certain ions within their walls.

A significant amount of energy is liberated when fresh water and salt are mixed. It has been calculated that dilution of a cubic meter of fresh water per second in a large volume of sea water dissipates about 2.25 megawatts of power. Put another way, for each pound of fresh water which mixes with salt water, about 800 Btus are released, making this the most potent of ocean energy resources.

This energy can be conceived as equivalent to a 790-ft. waterfall at the mouth of every river in the world, calculates Gerald L. Wick of Scripps Institution of Oceanography. If only 30 per cent of the osmotic potential of half the flow of the Columbia River were harnessed, it could produce 2.3 million kilowatts of electric power, he estimates in an article in a recent issue of *Energy*.

The total power available from the fresh water flow into the sea is on the order of three terawatts. This resource is doubled when one considers the power that could be extracted from saline lakes such as the Dead Sea and the Great Salt Lake or that to be found in salt pans, salt domes, or underground brines.

Harnessing Osmotic Power

The theoretical potential is huge, approximately equal to that of hydroelectric energy, and untapped. Moreover the technologies to tap this resource are amazingly simple. The key to harnessing osmotic power is the selective membrane which lets certain molecules through but holds back others.

The first method which will probably become practical is the "dialytic battery," described by John N. Weinstein of the National Institutes of Health and Frank B. Leitz of the Bureau of Reclamation in 1976. A dialytic battery reverses the flow of a conventional electrodialysis desalination unit. In the desalting process, saline water is run through a series of cells, electric current is supplied; fresh water pours out of half the cells and concentrated brine flows out of the other half.

In the dialytic battery, fresh water is poured into half the cells, salt water into the other half, and as they mix they generate an electric current. The cells are adjacent and separated with selective membranes. Half allow only positive ions (Na^+) to pass through while the other half allow only passage of negative ions (Cl^-). The membranes are arranged so that the positive ions flow in one direction and negative ions travel in the other, thus generating an electric current.

Drs. Weinstein and Leitz altered and operated an electrodialysis stack in this fashion. Extrapolating from the performance of their prototype, "assuming major improvements in technology but no fundamental breakthroughs," the scientists estimate that it should be possible to produce membranes (currently the most expensive element in the system) for $590 per kilowatt. When the other costs of such a system are included, this figure might double, they suggest. Assuming a ten-year life-time for the membranes, this translates to two cents per kilowatt-hour, Dr. Wick calculates.

While the dialytic battery has the advantage of development efforts into electrodialysis, another approach may have far greater potential for power generation, says Michael E. McCormick of the U.S. Naval Academy who manages the Department of Energy's modest program in this area.

This is the "Pressure Retarded Osmosis" (P.R.O.) method of energy conversion. Imagine a large chamber into which brine is pumped at 120 atmospheres pressure. A large pipe made of semi-permeable membrane — which lets water through but not salt — rests inside the chamber. This membrane pipe is filled with fresh water which forces through the membrane in an attempt to dilute the brine. The diluted solution then flows through a turbine from an exit port in the chamber, achieving a force twice that of the initial hydraulic pressure.

An Israeli scientist, S. Loeb, and his colleagues have experimented with this method using Dead Sea brine. They discovered that Dead Sea brines caused the membranes to deteriorate and that pressures over 100 atmospheres caused them to compact. To avoid these problems, they diluted the brine to half strength and operated at lower temperatures. Even with these inefficiencies the scientists estimated in the *Journal of Membrane Sciences* that operating and amortization costs came to only eight cents per kilowatt-hour.

In the Sun and on the Sea

Such a power generator need not be restricted to coastal areas. It can be applied simply to tap solar energy. After mixing in

the P.R.O. chamber and generating power, diluted brine is pumped into a solar still. Here fresh water and brine are separated and recycled through the osmotic generator. This system — under development at Intertechnology Corp. — would have a minimum of moving parts, no pollution, no combustible fuel, a minimum of noise, and salt would be its most toxic element.

Although all the uses for saline energy have been modeled for stationary power plants, it might be used to power large ships. Instead of fueling up with petroleum, ships could take on loads of salt. Of course, packaging over 70,000 square meters of membrane necessary to generate more than 10,000 horsepower may be something of a trick. But as long as the salt was evaporated from sea water in the first place, operation of these powerplants would not add to the sea's salinity.

Taking salt seriously as an energy source leads to some surprising conclusions. Dr. Wick and John D. Isaacs, also at Scripps, suggest that more energy could be produced from the salt in the salt domes along the Gulf Coast than from the oil and natural gas which has been found in them. Salt domes are one of the first places petroleum explorers search because they act as traps for oil and natural gas. Gulf Coast salt domes have produced from 55 thousand to 260 million barrels of oil. However, only in the highest yielding domes does the energy potential in oil outweigh that in the salt.

As a result, researchers in osmotic power are upset over proposals to pump brine out of some of these salt domes, dump it into the ocean, and replace it with petroleum as part of a strategic oil reserve. "Let's not ruin the brine fields with oil. We have a good resource there," says Dr. McCormick.

However, the researchers in osmotic power do not have much clout. There are only a handful of them. The Department of Energy is spending only $250,000 this year on five different projects. But Dr. McCormick, for one, is content with this state of affairs.

"I think that ultimately osmotic power will become practical," he says. "But at this point we should be conservative. If an article came out which said that this could produce energy at a price equal to that of coal (he feels the best that can be predicted is ten cents per kilowatt-hour) then a whole lot of people up in Congress would be hell-bent to pour more money into it. The program doesn't need that. It's under control. We're looking toward an operational system by 1985." □

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Water Quality Mismanagement

Ian C. T. Nisbet, who writes regularly for Technology Review, *is Director of the Scientific Staff of the Massachusetts Audubon Society. His Ph.D. in Physics is from Cambridge University.*

In the five years since the passage of the Federal Water Pollution Control Act Amendments of 1972 (F.W.P.C.A.), a new water pollution crisis seems to have arisen each month, if not each week. Kepone in the James River. Mirex in Lake Ontario. Polychlorinated biphenyls (PCBs) in the Hudson River, in Lakes Michigan and Ontario, and almost everywhere else. Sewage on the beaches of Long Island. Carbon tetrachloride in the Ohio River. Asbestos in the drinking water of Duluth. Lead in the drinking water of Boston. Carcinogens in the drinking water of New Orleans, Miami, and nearly every other major city. Oil spills here, there, and everywhere.

Water pollution problems were even worse prior to 1972. During the 1960s the study of toxic chemicals was overshadowed by more fundamental problems. Most major cities discharged raw sewage into rivers or harbors; the shores of Lake Erie stank of rotting algae; several rivers were declared fire hazards, and at least two caught fire; fish kills were frequent and fish-eating birds dwindled.

The Federal Water Pollution Control Act Amendments of 1972 were enacted in response to public indignation about the low and deteriorating quality of the nation's waters. The three years of delay by bitter debates in Congress about costs and feasibility kindled ambitious goals, and the short deadlines for achieving them, when the F.W.P.C.A. were finally passed in 1972. All major discharges were to receive some treatment by 1977; all waters were to be suitable for fishing and swimming by 1983; and discharge of pollutants was to be eliminated altogether by 1985. Just what Congress meant by this last provision is not clear, because "zero discharge" can never be attained in practice. However, the same goals and deadlines were reaffirmed by Congress in further amendments to the Act in 1977.

The F.W.P.C.A. is a very complex document. It has been questioned whether even the persons in Congress who put it together fully understood the relationships among its various parts. Certainly, if they did, they did not help the Environmental Protection Agency (E.P.A.) to implement it rationally.

The Act had five major elements:

☐ Individual discharges into navigable waters were to be regulated by permits, specifying amounts and constituents of permissible effluents and a schedule for compliance. The permit system (given the self-contradictory name, National Pollutant Discharge Elimination System or N.P.D.E.S.) was to be implemented primarily by the states, following effluent guidelines and national limitations to be established by E.P.A. Instead of continuing the attempt to achieve local goals for water quality, the effluent standards were to be industry-wide based on technological capabilities. "Best practicable technology" for treating effluents was to be in use by 1977, and "best available technology economically achievable" by 1983.

☐ Municipal treatment plants were to install "secondary treatment" (including bacterial decomposition and stabilization of wastes) by 1977, and "best practicable waste treatment technology" by 1983.

☐ Industrial facilities were encouraged to discharge their effluents into publicly owned treatment works, but were to be required to meet pretreatment standards established by E.P.A.

☐ The discharge of pollutants "in toxic amounts" was to be eliminated by establishment of specific effluent standards or prohibitions.

☐ Area-wide waste treatment management plans were to be developed by state, regional and local agencies to determine regional needs for waste treatment, and to include non-point sources of pollution as well as point sources.

In addition to these major charges, the Act included provisions for research, enforcement, planning, and inventories; and specific programs for lakes, thermal discharges, ocean discharges, dredging and filling, sewage sludge, etc.

New Construction Shadows Regulation

Perhaps the first thing to go wrong with the F.W.P.C.A. was that their implementation was assigned to existing regulatory agencies (the E.P.A. and state water pollution control agencies) which had been unable to maintain water quality in the past. The second error was the extravagant appropriation of federal funds to subsidize the building of municipal sewage treatment plants. The initial authorization of $11 billion for construction grants in the first two years was the main reason for President Nixon's veto of the Act.

In retrospect, it might have been better if Congress had reconsidered this authorization before overriding the veto. The consequence was that the construction of sewage treatment plants became the primary concern of E.P.A. in implementing the Act (indeed, it became the largest public works program in the nation). The Act thus reverted to an enormous exercise in classical sanitary engineering. The innovative features of the Act — the provisions for regional planning, control of non-point source pollutions, technology-based effluent standards, and regulation of toxic pollutants — were passed over in the rush to construct conventional types of waste treatment.

Only two parts of the Act have been implemented on schedule. More than 50,000 discharge permits had been issued under the N.P.D.E.S. system, and only 14 per cent of major industrial dischargers did not meet the standard of "best practicable technology" by the statutory deadline of July 1, 1977. At this time, more than $18 billion had been authorized for constructing municipal treatment plants, and 2,345 projects had been completed. These figures, however, exaggerate the actual achievements. The discharge permits were limited largely to the traditional sanitary parameters (pH, biochemical oxygen demand, and suspended solids). Only 33 per cent of sewage treatment plants were in compliance with secondary treatment requirements by July, 1977; the remainder were delayed by problems of siting, construction, or funding. In the 1977 Amendments to the Act, Congress found it necessary to authorize a further $25 billion for construction grants alone.

Too Much to Do, Too Little Time

The most conspicuous failure in implementing the F.W.P.C.A. has been in regulating toxic pollutants — as reflected in the list of pollution crises at the beginning of this article. E.P.A. has established effluent guidelines for about 15 chemicals (mostly metals) which cover five major industries. However, the Act required far more. The Agency was originally supposed to prepare a list of toxic pollutants within three months, and to establish standards for each pollutant within a further 12 months. The effluent standards were to provide "an adequate margin of safety" (without explicit consideration of technological feasibility or costs) and were to be achieved by all industries within the

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time limit of one year.

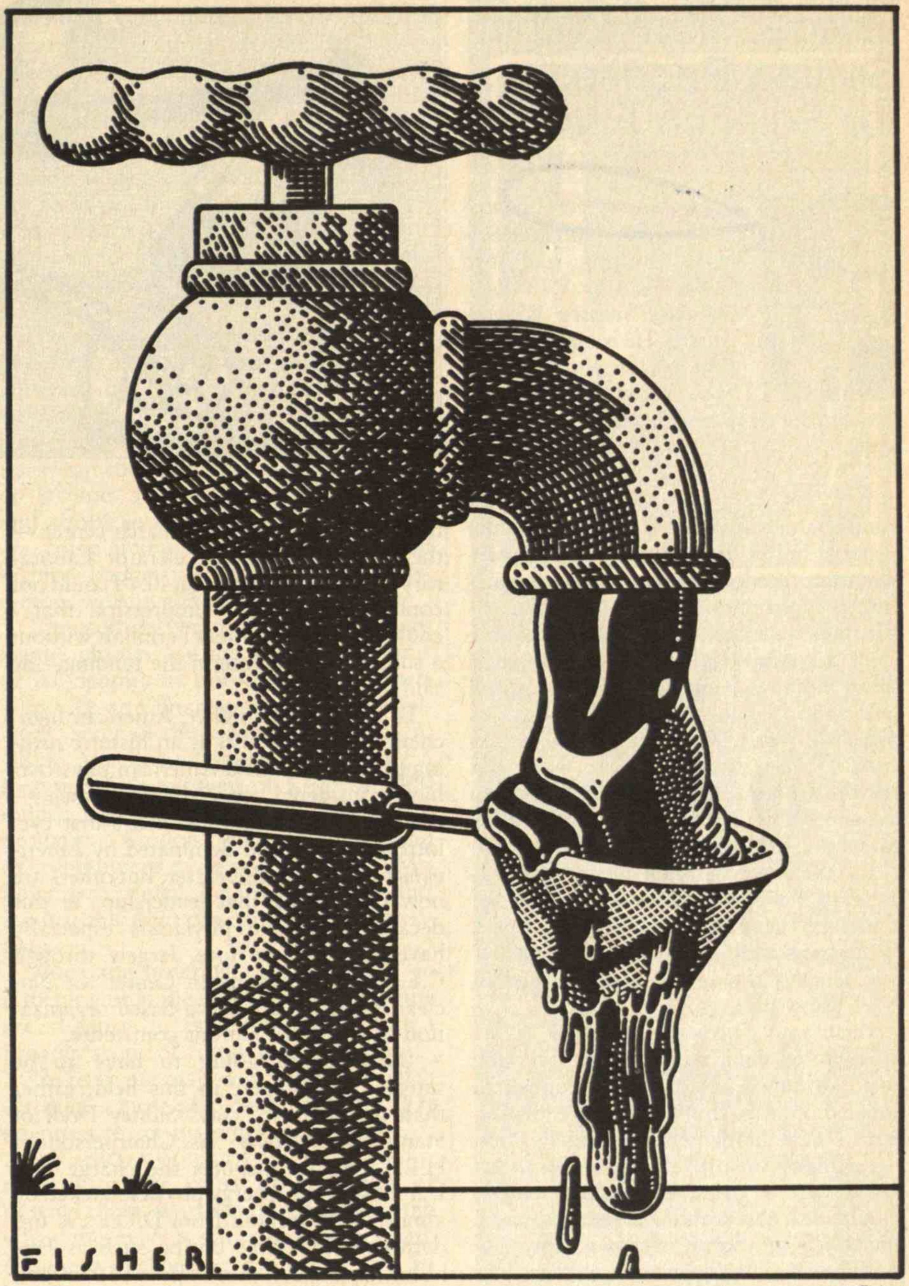
Faced with these impossible deadlines, and with thousands of potentially toxic pollutants to control, E.P.A. did little for several years. After being sued repeatedly by environmental organizations, E.P.A. agreed to establish effluent standards on an industry-wide basis for 65 pollutants. This agreement has been incorporated by Congress into the 1977 amendments to the Act, which now require the establishment of regulations in 1979-1980, and their implementation by 1981. Unfortunately, these deadlines are still too tight to harmonize with E.P.A.'s regulation of the same chemicals under the Toxic Substances Control Act.

E.P.A.'s failure to regulate toxic pollutants in a timely fashion is most glaring for those industries that discharge into municipal sewage treatment plants. Pretreatment standards for toxic pollutants in these effluents have been delayed more than six years beyond the original goal. One result is that the sewage plants themselves are now discharging unacceptable quantities of toxic pollutants. The sewage sludge, which could be a valuable natural resource, is often contaminated with toxic chemicals such as PCBs and heavy metals. In many regions, municipal sewage sludge is too toxic to be used for agriculture, cannot be disposed of without violating regulations governing waste disposal, and cannot even be incinerated without causing hazardous air pollution.

The establishment of area-wide management plans (Section 208 of the Act) has also suffered. The issue is politically volatile, because an effective regional plan for managing water quality would regulate not only point sources, but also agricultural practices, highway construction, mining, forestry, and urban and suburban development. These activities are not only major sources of water pollution, but are the major bases of regional economies. This section touches the heart of the environmental issue: pollution results from all economic activity, and cannot be controlled without extensive management.

E.P.A. has treated this area of the Act very cautiously, providing minimal guidelines and funding, and delegating planning authority to local agencies. As a result "Section 208 planning" has been no more than a vehicle for local political activity and local economic development. Attempts to put teeth into Section 208 planning are often resisted by the argument that Congress did not intend to legislate land-use planning in the guise of water-quality management. Unfortunately, that is exactly how local politicians and entrepreneurs have been using it to further their own interests. Moreover, even the construction grant program for sewage treatment plants has been similarly used as a tool in land development. E.P.A. has been too willing to fund sewage treatment plants with excess capacity "for future growth," thereby promoting urban development in areas that would otherwise have been unsuitable.

The rational way to have implemented the F.W.P.C.A. would have been to establish regional water-quality management plans first, then to establish permissible effluent standards for each pollutant and each industry, and finally to build the treatment plants needed to achieve the goals for water quality. With the encouragement of the Congress, E.P.A. has implemented the Act in exactly the reverse order. By doing so, it has encouraged unwise development of land, promoted the private interests of politicians and developers, imposed treatment standards for point sources unevenly, extended the exposure of the public to hazardous pollutants, and frustrated the achievement of national goals for water quality. ☐



Mark Fisher

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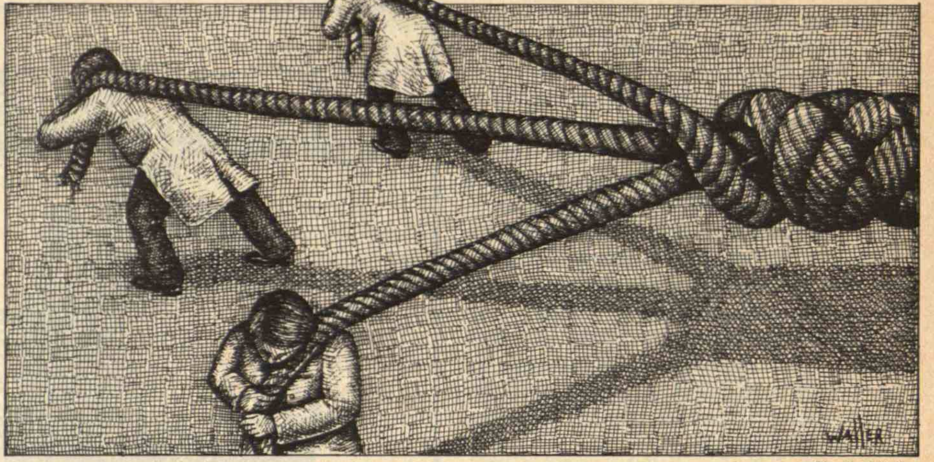
Divided from Within: Setting Priorities for Science Funds

~~Robert C. Cowen, Science Editor of the Chri~~stian Science Monitor, won the 1977 A.A.A.S.-Westinghouse Science Writing Award. He is former President of the National Association of Science Writers and is a regular contributor to the Review.



Charles Waller

Congressman Edward P. Boland put the matter bluntly: he says that this age presents unprecedented opportunity for scientific exploration. But American scientists must face the fact that they probably can't accomplish all they might in their short lifetimes. Congress has designated other priorities for the limited funds at its disposal. In fact, Mr. Boland says, the scientists' best strategy is to sort out priorities among themselves in order to present Congress with intelligent guidelines with which to make grants.

The Massachusetts Democrat was addressing his remarks to a meeting of planetary scientists. His message applies to scientists in all fields, but is particularly pertinent to those scientists engaged in high-energy physics.

Their new discoveries, as well as the progress in theoretical physics over the past half decade, have been phenomenal. Some physicists think they have discovered a new fundamental force. Further, experiments using the generation of atomic accelerators now being planned should clearly reveal this force, if it exists, and other significant unknown aspects of the subnuclear world as well. Anticipation of this runs high.

Losing the Edge to Europe

But this, too, is a field in which scientists have set their own priorities under the auspices of High-Energy Physics Advisory Panel (H.E.P.A.P.) of the Department of Energy (D.O.E.). The result is a budget that some members of the physics community have labeled poverty-level, suspecting that it will literally hand the laurels of discovery to the foreign competition.

To protest this, one of the world's leading physicists, Robert R. Wilson, has resigned his position as Director of the nation's most prestigious research center — the Fermi National Accelerator Laboratory (Fermilab) at Batavia, Ill. "I could not continue to give the impression that I could responsibly direct Fermilab without a substantial increase in the funding," he said.

To add to the conflict, American high-energy physics is also at an historic turning point. It is a field American physicists have considered especially their own — created with Ernest Lawrence's first cyclotron in 1930 and dominated by Americans for 40 years thereafter. But others are now challenging that leadership. In this decade, European physicists especially have come to the fore, largely through C.E.R.N., the European Center for Nuclear Research, a Geneva-based organization to which 12 nations contribute.

"Now we're going to have to be satisfied to compete in this field, rather than dominate it," says Sidney Drell of Stanford University. As Chairperson of H.E.P.A.P., he disputes the charge that U.S.-based high-energy physics, backed by almost $300 million from D.O.E., is undernourished. Some critics, such as Fermilab supporters, think this is $50 million short of what is needed. But Dr. Drell holds that the administration's fiscal year 1979 budget request provides for a very healthy program. However, it is a "minimum viable level" of funding, he adds, that will slow the pace of experimental work for Americans and pare down the Americans' share of prizes more than some physicists would like.

Milton G. White of Princeton University is one such concerned physicist. As Chairperson of the Board of Trustees of University Research Association, which runs Fermilab for D.O.E., he admits to an understandable partisanship. Yet he holds that H.E.P.A.P. has unwisely discounted the competition. American physicists will too often find themselves following up pioneering work done abroad, he says, and he fears a decay in quality, as well as a decline in quantity, of American work.

Sub-Atomic Bumper Cars

In high-energy physics, a large part of the game is in revving up enough effective energy to excite the interactions of sub-atomic particles most interesting to experimenters. Shooting particles at fixed targets is not necessarily the best way to do this because much of the original energy of the incoming particle is simply converted into kinetic energy — or velocity — of the interaction products. Only a small part is typically available for exciting new particle states.

But bang protons of equal energy together in a head-on collision and there is no net momentum between them to be accounted for. All of their energy is available for exciting new particle states. Hence the growing interest in facilities in which a pair of proton or electron beams circulating in opposite directions can be made to collide.

By this new method, as well as by beefing up the energy of fixed target particle accelerators, physicists think they soon can reach an energy range that will begin to answer some major puzzles. For example, particles such as the proton and neutron — which respond to the strong force that holds atomic nuclei together — seem to be made up of simpler particles called quarks.

These quarks have never been seen as isolated particles. It begins to look as if they are governed by a new kind of force. All other known basic forces, such as the strong nuclear force or the electromagnetic force, are strongest when particles are close together. But with the quark, the

binding force seems to be weakest when two quarks are close, and strengthen as they move apart. Theorists now think that this new kind of force, if it exists, would prevent quarks from ever appearing as isolated particles.

The higher range of energies that accelerators will soon be able to achieve should reveal this force. Dr. Wilson has observed, "If all that energy doesn't produce a quark, then at some stage we must admit that we have experimentally demonstrated a new force, and that's as interesting as a new particle — or more so!"

An Undeveloped Potential

Right now, Fermilab has the highest-powered energy accelerator in the world — a 500-gev proton synchrotron. C.E.R.N. is a close second with a 400-gev machine, plus a facility in which beams of 28-gev protons can collide head-on. Several more colliding-beam facilities for protons or electrons have been built or planned in Europe. In the U.S., the Stanford Linear Accelerator Center (S.L.A.C.), which now has a 4-gev electron colliding-beam unit, is waiting for a facility in which 24-gev electron-positron beams will collide. And at Brookhaven National Laboratory in Upton, Long Island, a facility called Isabelle is to be built in which proton beams can collide at energies ranging from 30 gev to 400 gev.

It is this that has galled Fermilab. Fermilab is poised for major improvements of its own. It has pioneered development of superconducting magnets, and nurtured this difficult technology to a point where such magnets now can be used to upgrade the accelerator to 1,000 gev. Yet, because such magnets use so little power, they could cut the lab's annual electric bill by $5 million or more. Fermilab has plans to combine the present accelerator ring and the superconducting ring to make a colliding beam unit in which protons with energies as high as 1,000 gev each could meet head on. That's equivalent to a fixed target accelerator of 1 million gev. What's more, Dr. Wilson would eagerly install the superconducting magnets within fiscal year 1979 if only he had another $10 million in his budget to do it.

But he doesn't have that $10 million. H.E.P.A.P. gave Brookhaven's Isabelle first priority, recommending that Fermilab's improvement be stretched out over a longer period than Dr. Wilson thinks necessary. Thus Fermilab's low operating budget is forcing it to cancel not only experiments already approved, but also its hopes to get the jump on the competition in accelerator power.

Fermilab supporters have been lobbying to get Congress to reorder the H.E.P.A.P. priorities manifested in the administration budget. At this writing, it was impossible to judge their prospects. Whatever the outcome, the high-energy physics saga has already made a basic point. It is no easier for scientists to set priorities for themselves than it is for Congress to do it for them, when the possibility of deliberately foregoing major research opportunities exists.

The situation must seem ironic to European physicists whose national governments have informed them that they must not expect to keep up with the Americans. Thus physicists in individual European countries have reluctantly given up facilities at home to pool their funds and efforts in C.E.R.N. Now Americans are complaining that this multinational facility's budget is larger, making C.E.R.N. a more worthy competitor.

The conflicts within the ranks of high-energy physics is a microcosm that hints of the agonies in store for any scientists who take up Congressman Boland's challenge. Some of the planetary scientists to whom Mr. Boland spoke were urging a long-term commitment of $300 to $400 million a year to a planetary exploration program. "We don't even make that kind of commitment to New York City," Mr. Boland exclaimed. Yet the D.O.E. is offering just this kind of security to the physicists.

When the ordering of priorities is so difficult within the ranks of one field, how are scientists to establish them across a broader scope of research possibilities?

There is no easy way to select which disciplines most need funding, but to ask scientists to set priorities is a cop out. It neatly relieves Congress and the Administration of the onus of choosing or downgrading worthwhile projects. And when the need is for vision, statesmanship, and intelligent compromise, this attitude necessarily evokes the partisan goals of the specialists.

The time has come for a fundamental reassessment of the role of basic science in the United States — its needs, its value to society, and its claim on the nation's resources.

The best solution will be a balance between the aims of the individual scientists and the most pressing needs of the nation. Somehow, the decision-makers in government and the scientific community must come together on a broader level than is afforded by specialists, advisory committees or budgetary hearings. □

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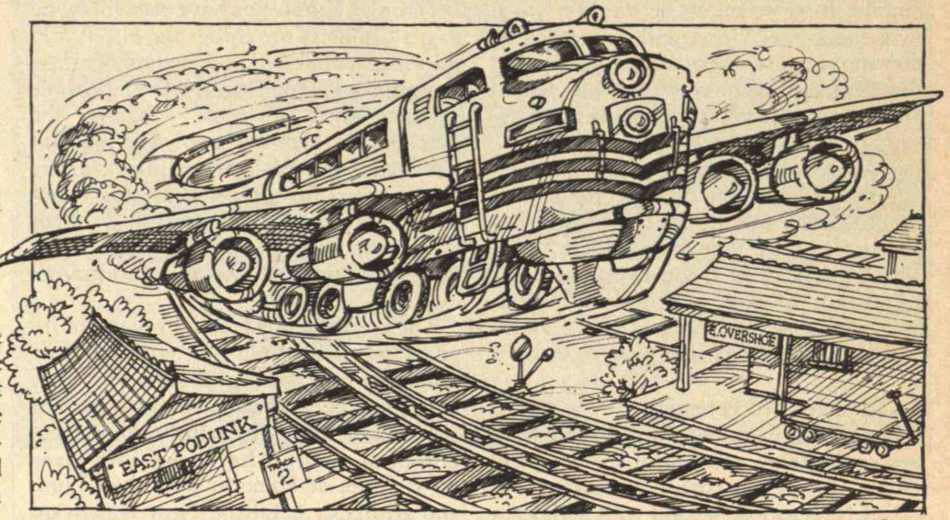
Airport or Plane Station?

~~*Airport Systems Planning*~~
~~Richard de Neufville~~
Cambridge: M.I.T. Press, 1976, xvi + 201 pp.; $14.95

Reviewed by Jonathan Schlefer



Ed Parker

Union Station — before it became the National Visitors' Center and its marble floors were swathed in wall-to-wall carpet — was unmistakably the gateway to the nation's capital. The great main concourse, with its vaulted ceiling, solid wooden benches, newspaper stands, and a voice echoing importantly about tracks, arrivals, and departures, seemed an entry to the world. To reach your train you passed into the gate area, also vaulted but with rough floors and no heat. Porters scurried with baggage carts, a clock told the time, and the numbered tracks spread out in rows. Everything made sense; you knew where you had come from and where you would go. For 100 years, those wicked railroad barons built monuments that served with dignity and clarity.

Compare old train stations with airports which are incomprehensible from all points of view except, appropriately, the air. Can anyone untangle the confusion at Kennedy International? Competing for attention are signs, blinking lights, motels, highways, traffic, and, scattered among them, discrete terminals designed by some of our foremost architects. In an airport, you're thankful if you and your bags are finally reunited — never mind by what devious means they are routed, through what branching corridors you trekked to meet them, or along what sinuous routes the limousine will bear you away.

Over-reaching Technology

The function of an airport — to deliver passengers and baggage between ground transportation and planes — is hardly different from that of a station. Then why do airports have to be so complicated?

Richard de Neufville argues that, to begin with, airports are in the web of suburbia. In San Francisco, for example, only 20 per cent of the passengers and little of the freight come from downtown. (When the old produce markets were razed in the 1960s, the wholesalers moved to a new site — a freeway exit from the airport.) Terminals are built to the scale of the car, not the pedestrian. Dr. de Neufville notes that designers typically allow 4 in. of curb space per 1,000 passengers per year; for a big city airport trafficked by 10 million passengers a year, this amounts to a half-mile. Hence arrival and departure lanes on different levels, dispersed terminals, and vast parking structures.

The airplane's shape and size complicates the terminal's design still more: docking stations require an even longer distance than curb space for autos. The usual solution, of which Chicago's O'Hare is a notorious example, is to extend long fingers out to the gates from a common hall where tickets are purchased and baggage checked. These fingers are the branching corridors you walk down. At Dulles, mobile lounges carry passengers to the planes. Unfortunately, these foster expense and delay, particularly for the jumbo jets which may require several trips to fill.

When Thomas Sullivan was named Director of the new Dallas-Fort Worth airport, he told *Newsweek*, "I made a list of all the things that went wrong in the New York airports and set out to change them." He and the architect, Gyo Obata, devised a "gate arrival system," which, behind its semi-circular geometry, is essentially a vast chain — projected to be as long as Manhattan — of small airports servicing a few planes each. One can drive nearly to the plane's door. Perfect? Hardly. Dr. de Neufville points out that 55 per cent of the passengers at Dallas-Fort Worth are transferring from one flight to another. It's a long way from Wall Street to the Bronx, and the electric trains that shuttle passengers among terminals proved a lot more expensive and inefficient than expected. So if in some bleary hour of the night you find yourself at Dallas-Fort Worth, trudging amid a clutch of passengers down endless corridors, you can curse New York for not making that mistake first.

Many airport design problems have arisen through technologies that would have worked fine if only people hadn't been involved. Partly due to the spread-out plans (and partly due to technical bravura), a lot of automatic devices have been introduced to transport passengers and baggage from one place to another, often with little success. A report quoted by Dr. de Neufville on moving sidewalks found that the polite souls stepping up to them exhibited a deferential "after-you-Alphonse" behavior, which cut the manufacturers' estimated capacities almost in half. Other manufacturers have been equally over-optimistic. The automated baggage system at Kennedy Airport's Pan American terminal — not an atypical case — should have been twice as large. For their part, airport planners have predicted traffic as confidently as the manufacturers predicted capacity — only to find, five years later, that they were off by half. And, counting inflation, costs frequently run three times what was expected. Many airports remain overcrowded; elsewhere expensive terminals lie idle.

Theory vs. Common Sense

These design blunders — payed for by passengers and government tax exemptions — are rather like the airlines' absurd scheduling policies. The agent inevitably tells you the plane will arrive at, say, 12:33 — never 12:30 or 12:35, presumably on the theory that if we can land instruments on Mars, we can get airplanes on the ground to the minute. We can't. one-third of all flights are late by over 15 minutes, and virtually none arrive at that

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magical 12:33, give or take 30 seconds.

Dr. de Neufville notes the difficulties airport designers labor under: a tenfold expansion in traffic since World War II; a doubling of traffic in the time it takes to build a terminal; political pressures; unexpected technologies. He argues that mistakes are inevitable, and the simple, common-sense solutions are best. There is no evidence that elaborate computer traffic predictions, sensitive to hundreds of variables, are any improvement on rougher estimates whose logic is readily followed. Being cheap, the rough estimates can be repeated throughout design, and no decision should be made before necessary. The decisions that are made should be as flexible as possible.

He suggests that finger plans, gate arrival systems, and mobile lounges be pragmatically combined, rather than made the subject of theoretical disputes. The finger plan is good for transfer between flights; the gate arrival system is good for a commuter run and is, in fact, successfully employed at the Eastern Shuttle terminal at La Guardia. Mobile lounges are useful as hedges against fluctuating loads or uncertain growth. A vacant wing of an airport ties up just as much capital as a full one, but mobile lounges can easily be added and, since their expense is in operating and maintenance, cost less when idle.

It is perplexing that of all the nation's airports, only Dulles appears as rational on the ground as in the air. With the inverted vault of its roof standing over the Virginia countryside, its lights gleaming through windows, it is as simple as a train station. Conceptually, it *is* a train station, a box where you board mobile lounges. Is a minor saving in time and cost really worth those sprawling fingers and miles of gates that travelers elsewhere must make their way through, to and from our cities?

Every paragraph of Dr. de Neufville's book offers important insights, clearly stated; only one point remains bothersome. The terminals he proposes, though more functional, would be as unintelligible to passengers as those we have today. This muddle of circulation routes is not the way to welcome a traveler or send him on his way. The railroad barons were generous, at least, in the buildings they gave us. Airport planners could afford to sacrifice a little efficiency to dignity.

Jonathan Schlefer is Assistant Editor of Design News. *His M.A. in architecture is from the University of California at Berkeley.* ☐

The Conservation Response

Energy Demand Studies: Major Consuming Countries
Workshop on Alternative Energy Strategies; Paul S. Basile, ed.
Cambridge, Mass.: M.I.T. Press, 1976, xiv + 553 pp.; $15

Energy Supply/Demand Integrations to the Year 2000
Workshop on Alternative Energy Strategies; Paul S. Basile, ed.
Cambridge, Mass.: M.I.T. Press, 1977, xiv + 706 pp.; $29.95

Reviewed by Lee Schipper

Some people have long believed that gross national product (G) and energy use (E) are rigidly coupled. Casual inspection of graphs of the two over time or from many countries suggests a high correlation. But a closer look reveals high variability in the E/G ratios for different regions and countries, or for a single entity over time. The U.S. E/G ratio has fallen considerably for decades.

All this would be of only passing interest if the "rigid coupling" theory were not constantly invoked as an argument *against* the feasibility, desirability, or practicality of considerable improvement in the efficiency of energy use. As a result of this misunderstanding, many of us are investigating the differences in patterns of energy use to answer a number of questions. For example:

☐ How do different countries invoke energy as a function of prices, economic output mix, and technology?

☐ How do lifestyles, demography, climate, and policies alter a country's energy use?

☐ How much energy is consumed in imports and exports of non-energy goods and services?

☐ What can one country learn from other countries?

Unfortunately, until a few years ago the literature contained little data — other than regression of E versus G — that could answer these questions. To be sure, curious and often unsupportable inferences about the "link" between E and G appeared now and then in *Electrical World*, energy industry pamphlets, and scholarly papers. Even the environmentalists played the game, claiming differences in E/G among countries as sole proof that energy could be saved at will.

Working with A. Lichtenberg, I compared energy use in the U.S. and Sweden (*Science*, December 3, 1976, p. 1001), rejecting the simplistic E/G approach. We broke down our data into dozens of categories: outputs, activities (miles of travel, tons of steel), intensities, and energy consumed per unit produced, and found many significant differences between the countries. One criticism we faced was the possibility that our sample (Sweden and the U.S.) was too small. But when we did the bulk of our work in 1975 and early 1976, little data was available for other countries.

Exhaustive Detail

It is a pleasing surprise, then, to read the report of the Workshop on Alternative Energy Strategies (W.A.E.S.), which continues this work over 15 countries. Now all of us can play with a massive compilation of important energy *use* data. The purpose of the W.A.E.S. study (directed by Carroll Wilson, Professor of Management at M.I.T.) was to gather and assess the expertise and views of industry and government élite in the developed nations on future energy needs. For the first time, a group has attempted to integrate demands from a large part of the world. Experts in each country assembled data into more or less uniform categories, explaining policies and assumptions. In all, the study produced three volumes of summary, data, and analysis.

Energy Demand Studies presents country-by-country summaries and countless pages of data sheets submitted by the correspondents in each country. The scenarios and forecasts all look no further than 1985 and are based upon a range of oil prices and vigorous versus restrained conservation policies. The means of estimation — intricate models or guesswork — vary from country to country. Little effort is made to debate supply options or conservation policies; instead a collection of data and expectations are simply brought forth.

How can one evaluate such a volume? Clearly I can't try to sort out the goods and evils of the *de facto* policies discussed. That task is reserved for and recommended to each reader. I could complain that the élite, industry-oriented representation offers a distorted view in any particular direction, but there's much more conservation spelled out in W.A.E.S. than *Electrical World* would ever consider.

The problems with the first volume of W.A.E.S. lie in its usefulness to readers. The W.A.E.S. data, carefully analyzed,

show some interesting facets of consumption that deflate the "rigid coupling" theories. But careful study is a prerequisite, for W.A.E.S. offers few cross-sectional analyses to the reader: it is up to us to set to work. Fortunately, most W.A.E.S. data is broken down into exhaustive detail; herein lies the volume's potential value. By assimilating data on a particular facet of energy use, one could, in theory, answer the questions I posed initially. But our attention is distracted by too much data in some cases. In others, data are insufficient or inconsistently organized. These problems are due both to the poor data bases available and — unfortunately — to carelessness or oversights on the part of the W.A.E.S. staff.

For example, the important breakdowns of auto use by city and rural areas, or by distance or trips and auto weight — all crucial to the study of transportation — are usually unavailable or buried in a country's archives. Other important data are equally difficult to assemble: for example, number of people per dwelling and dwelling size by type, both indications of a country's housing standard. This standard can be compared to energy use to yield a measure of residential energy conservation.

More distressing, though, are certain omissions of data that W.A.E.S. did not solicit. There are no figures for the number of cold days when heating is required, energy prices for each fuel, or personal consumption expenditures. All are necessary if we're to review the effectiveness of present and future policies and examine at least superficially the issues raised by various living standards. The amounts of energy used for heating in Sweden and the U.S., for example, are nearly the same. Sweden has the same space per capita in apartments and detached homes (within 10 per cent of our own), but Sweden's climate demands nearly twice as much energy for heat as ours: thus heating in Sweden is significantly more efficient than in the U.S., as Dr. Lichtenberg and I discovered. But W.A.E.S. can't tell us this because one of the components of demand — climate — is not given.

The sections devoted to industry also suffer significant omissions: for example, the nature and energy intensity of raw materials processing. Not all countries show both physical and monetary production outputs from heavy industry. Aggregation of raw steel and rolled slabs can be misleading. Moreover, what steelmaking processes are used? Do countries import pulp and pig iron, or start from trees and rocks? Finally, what fraction of raw materials and other energy-intensive products are imported or exported? These questions are answered for only a few countries, yet they are central to the debate of energy's relation to GNP and more important, they show how efficiently energy is used in an economy. Sweden, for example, exports about 9 per cent net of the energy it consumes, amounting to 12 per cent of the B.t.u. content of its oil and coal imports. This figure should have been estimated for every country in the W.A.E.S. study.

The numerous small deficiencies in W.A.E.S. data limit its usefulness. You may need other sources of data as well. But the W.A.E.S. report is nonetheless the most complete reference to date, and suggests some important conclusions. For example:

□ The auto is the world's dominant mode of land travel; people in most countries drive less often and in much smaller cars than Americans, but they still drive.

□ Most European nations and Japan are more, not less, dependent upon energy-intensive industries than we. The countries of western Europe use less energy per dollar of GNP not because they produce cuckoo clocks but because they produce more efficiently than we (subject to details of product mix), drive smaller cars less often, and enjoy (with a few exceptions) fewer appliances, in somewhat smaller homes. Social services and insurance — *not* themselves energy-intensive enterprises — are generally more prevalent in most of Europe than in the U.S.; these amenities replace some of the miles (and tons) of auto travel and cubic feet of frost-free refrigeration in the U.S.

□ The U.S. is far less dependent upon imported energy than nearly every other country.

W.A.E.S. does not tell us all these facts directly. We have to dig into their data, change units, normalize to per capita values, and often curse certain present-day values that are missing or hidden.

Gas Guzzlers

The second volume of W.A.E.S. data focuses on energy supply, supplemented with still more demand projections. Since the forecasts are extended to the year 2000, the material is less valuable to the reader interested in the present. And again, the reader is encumbered by lack of synthesis. For example, Finland's results are presented in Finnish marks, rather than translated into some standard currency per capita for the sake of comparison. However, most of the reports give splendid bibliographies, a boon for those who wish to investigate further.

One rather neat piece of exposition is worth reporting. Addressing the question of how much "conservation" is implied by the various scenarios, the authors of the Danish report note wisely that simple exponential projections of economic growth and energy use beyond even the year 1985 are largely meaningless. We don't know that much about the future even if we would like to. Thus one could not simply project yesterday's energy use and growth rates into the future to find a "base case." But using the nifty W.A.E.S. worksheet methodology, one *could* project rates of activities at any desired level of detail: how many cars, how many miles, and so forth. To find out how much energy is "saved" in a given scenario, one has only to vary the energy intensities which, though not completely independent of activity levels, nevertheless allow an estimation of the components of total energy demand.

President Carter, who complained last summer about the spread of gas guzzlers, would have been less uneasy if he had bothered to measure conservation according to the W.A.E.S. strategy. Given the number of miles driven by Americans that summer, gasoline demand was far less than it would have been if we were still driving pre-1973 autos. If gas consumption hasn't dropped as precipitously as expected with the new, more energy-efficient engines, it is because cars cost less per mile to drive and are thus driven a little farther. Policymakers should study such examples carefully before they bemoan the state of energy conservation.

As the W.A.E.S. data show, lifestyle influences energy demand as well as climate and the structure of a nation's industrial mix. So one wonders why the U.S. seems reluctant to stimulate more conservation via prices and policies.

The most important lesson of all these figures is that a menu of options to decrease energy demand exists. There is a way out of the energy quagmire.

Moreover, the W.A.E.S. work helps to silence many of the cynical critics of energy conservation whose arguments are almost always based upon false assumptions of the relations between energy and GNP. Although these assumptions continue to be proclaimed, the government, at last, seems to have rejected them. For any energy policy to succeed, however, we must know our own energy-use patterns intimately. Methodologies such as those presented in W.A.E.S. are a good start.

Lee Schipper is an energy conservation researcher at the Lawrence Berkeley Laboratory, spending the 1977-78 academic year as a guest of the Royal Academy of Sciences, Stockholm, with support from the Fulbright Commission. His own "The Logic of Energy Conservation" (with Joel Darmstadter) appeared in the Review *for January, 1978.* □

Continued from p. 7

I would recommend at present that about 70 per cent of the heat load be filled by solar. Then oil or gas would be the sensible auxiliary fuel. But when the substantial capital savings in off-peak electric use are better appreciated with substantial rate reductions, it may well be that the solar house with its large heat storage capacity will be the ideal recipient of off-peak power. Beyond this point, what does Mr. Hill have in mind for auxiliary fuel in the year 2000?

Illusions of Extraterrestrial Intelligence

Two aspects of Robert C. Cowen's February column, "Close Encounters of the First Kind," caught my attention.

In quoting from the study of the Search for Extraterrestrial Intelligence (S.E.T.I.), Mr. Cowen says that "life appears to have developed on earth as soon as seas formed and chemical evolution had provided the building blocks. ... This leads many exobiologists today to look upon life as a very likely development."

When chemical evolution first provided the building blocks, all asymmetric organic molecules would have been present in equal numbers of levo (L) and dextro (D) versions, averaged over the planet. If life is "a very likely development," it would have arisen frequently throughout the planet. Due to the molecular asymmetry, primitive organisms would either use L or D isomers, but not both. One would therefore expect a fairly even distribution of organisms using each of the two types of isomers.

However, in all known life (both extant and extinct, from molecular through man), only L amino acids are used to construct proteins. This implies that all life has descended from a single original source, instead of taking form in nearly every little puddle of primordial organic soup. Thus one should question the view that the existence of life is such a sure thing.

Should this be ignored, the project as presented still seems to be irrational. Mr. Cowen states that "the S.E.T.I. analysts are not asking for commitment of major resources to an uncertain enterprise." This would seem to conflict with the approach he previously stated.

Normally, sound economic planning would use limited funds for investigatory trial balloons. The effort is expanded only if the results are promising. The S.E.T.I. proposal progresses in reverse. The original trials would cost a few million dollars. "Only if this modest effort failed to turn up anything would S.E.T.I. appropriate a few existing radio telescopes for a full-time search. And only if this stepped-up effort also failed would development of costly giant systems ... be urged."

Clearly, the response to a positive result would not be to fold up the S.E.T.I. program. This means that no matter what results occur, we would be tied into a long-term commitment of major resources, should we take up this search.

My limited encounter with S.E.T.I. and its goals leads me to agree with the views expressed by Charles C. Ryan in his editorial in the current issue of *Galileo*. "The enigmas of the universe can be eventually resolved without a U.F.O.'s magical mystery tour. That's not being ethnocentric — it's called optimism."

Avi Ornstein
New Britain, Conn.

Get It Together

In the January *Technology Review*, I note that Kenneth Boulding is attempting to find ways to employ people (scientists) during active later life. In another column, Robert Cowen suggests that the declining college enrollments of recent years means an inadequate pool of scientific talent is being educated.

I suggest that Mr. Cowen has defined a problem and that Mr. Boulding has proposed an answer. The two ought to get together and set up some mechanism to keep our scientific and technological productivity high.

E. G. Sharkoff
Sparta, N.J.

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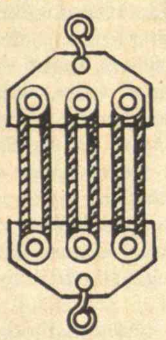

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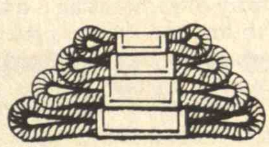

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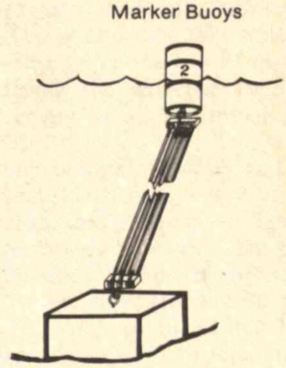

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Trend of Affairs

Transportation 20

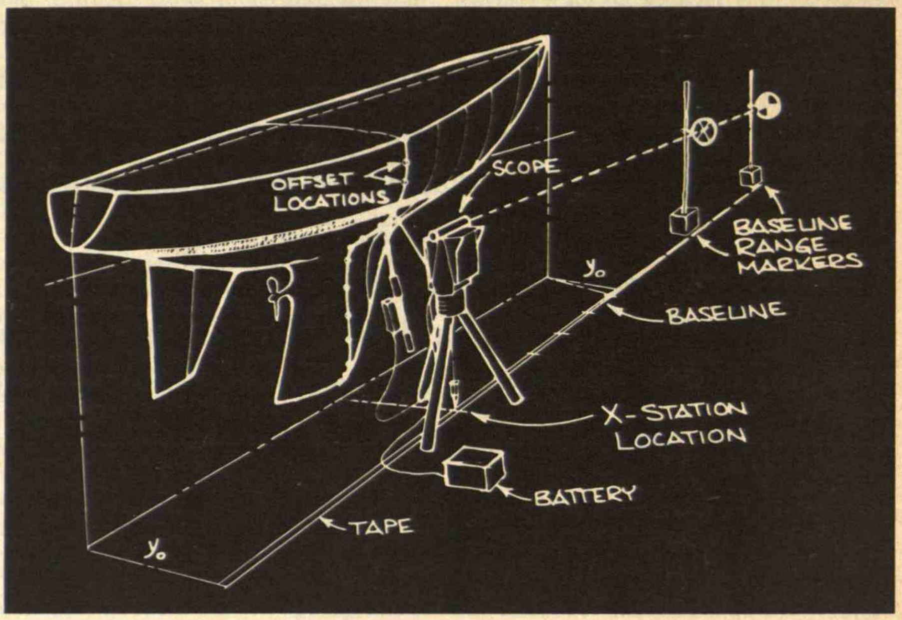
Taking precise measure of floating bodies . . . Dr. Salter's super subway.

Aerospace 22

Consequences of a rain of satellites . . . A strategy to slow the arms race.

Energy 24

Reactor fuel: supply shortfall in the near future? . . . The energy embodied in building materials.



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Transportation

A Magic Wand to Measure Yachts (and Their Sailors)

The longer a yacht, the larger its sails, and the narrower its beam, the faster it should sail. But how much faster? It is a thorny problem for the competitive skipper who wants to pit his skills in his 32-foot sloop against his neighbor's in a 48-foot yawl, and the history of yacht racing is a history of efforts to find the elusive, perfect formula by which to measure a skipper's skills in contrast to the qualities of his craft.

Until this year, the best answer for ocean racing has been contained in the International Offshore Rule, which specifies how certain measurements of length, beam, sail height and area, and hull shape and displacement are to be translated into advantages and then into racing handicaps. But when more than 50 yachts set sail from Marblehead, Mass., in the time-honored Bermuda Race this summer, their handicaps had been calculated on the basis of their hull shapes by a computer program and hull measuring system developed at M.I.T.

It's the first time that the frustrating issue of handicapping has had "a real input of scientific thought," says Vincent Monte-Sano of the prestigious Larchmont Yacht Club, which was host to the first general explanation of the system, arranged by the M.I.T. Club of Fairfield County, Conn., early in the spring. A panel of leading yachtsmen was on hand to learn about the work of Professors Justin E. Kerwin and John N. Newman of M.I.T., divising the new Measurement Handicap System for the U.S. Yacht Racing Union under the Institute's H. Irving Pratt Ocean Race Handicapping Research Project. Olin J. Stephens, a dean of American yacht designers, found the system a "radical change" from traditional methods; but he supported it "just as strongly as I know how." So did Richard C. McCurdy, Vice Commodore of the Cruising Club of America.

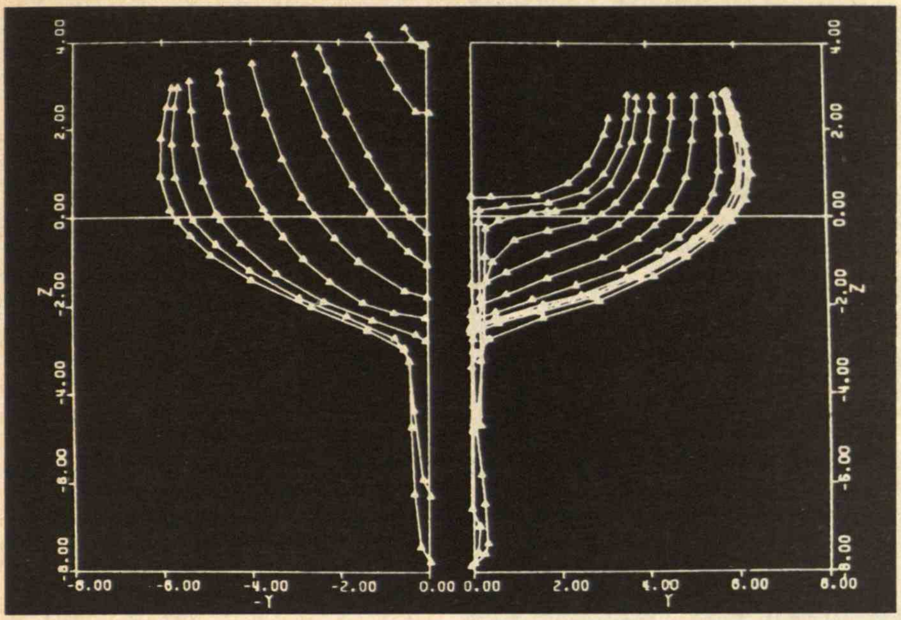
The new Measurement Handicap System is in reality three separate analyses correlated into a single system, explained Mr. Stephens:

☐ A new computer-based method of determining the hydrodynamic characteristics of any yacht's hull, an integral part of which is a new and greatly simplified hull measuring system.

☐ A computer program that translates these hull characteristics into a yacht's performance expectations expressed in terms of hours and minutes elapsed in sailing a race, be it around three offshore markers or across the Gulf Stream between New England and Bermuda.

☐ A translation to these two M.I.T. achievements into a new Measurement Handicap System, the rules under which

As the tip of the hand-held measuring wand touches an "offset location" on the hull, a single-channel digital tape recorder encodes the polar coordinates of the location, relative to the position of the tripod. The mechanical measuring system is carefully aligned with a sighting level ("scope") to follow a baseline on either side ("scope") to follow a baseline on either side of the hull parallel to the hull center line. (*left*) Data from each "X-station" along the baseline provide the means for a CRT display of various hull cross sections coming (left contours) and going (right contours). (Drawing at left: Owen H. Oakley, Jr.)



yachts were given their handicaps at the start of the Bermuda Race, by the U.S. Yacht Racing Union.

To record the critical dimensions of a hull for a computer, Professor Kerwin has devised a "magic-wand"-like hull measuring tool. Align the instrument with the stem of the hull, then touch its wand to the hull at several points on each of 20 or 30 sections from waterline to keel, defining a total of perhaps 750 points on the hull. The computer replies with drawings of each section and an expression for hull hydrodynamics — resistance to motion — under four conditions: moving through the water upright as in tow, moving upright through the water in sailing trim, and sailing at 2° and 25° heel.

Give the computer an estimate of the conditions to be encountered during a race — the length of each leg, the heel at which the boat will be sailed in each and the force in the wind — and it will reply with a calculated speed of the boat for each leg of a race and a minimum elapsed time from starting gun to finish line. If the race committee has given the computer a good estimate of the weather conditions awaiting the racers, the computer has delivered the perfect handicap under which each should be sailing.

Conventional handicapping is based on careful hand-made measurements of a few selected points on a hull, and over the years yacht designers have learned to exploit this system to gain large handicaps for boats that don't need them. The new system — because it uses so many measurements that it really "sees" the hull shape in full — should have fewer such loopholes and opportunities for exploitation. And if some loopholes appear, says the U.S.Y.R.U., a change in the rules can be made by simply making a small change in the computer program.

Now that the problem of analyzing hull hydrodynamics is conquered, Professors Kerwin and Newman want to proceed with similar studies of other variables in yacht performance — making, for example, an aerodynamic model which will do for sails what the new hydrodynamic model has done for hulls. — *J.M.* □

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High-Speed Corridors Under the Continent

Crowded skies and a maze of highways frustrate the would-be traveler. In the future, to get from here to there quickly try the high-speed underground transportation system called Planetran.

Planetran could end the search for ground transport that can move as quickly as aircraft. With Planetran, a New Yorker could speed to the West Coast during lunch, spend an afternoon in conference, and return home in time for dinner.

This transcontinental subway system is proposed by ~~Robert Salter, Senior Physical Scientist at~~ the Rand Corp. He made his presentation to the American Association for the Advancement of Science in Washington, D.C., this winter.

Airborne jets waste an enormous amount of nonrecoverable energy as they rise to cruising altitudes, explained Dr. Salter. Planetran would take advantage of the environment of the upper atmosphere which favors high-speed air travel, but avoid the fuel-consuming ups and downs. Powerful air pumps would create a near vacuum — equivalent to 170,000 ft. altitude — within the Planetran's prestressed concrete tubes. Streamlined cars carrying up to 200 passengers could streak through these tubes at thousands of miles per hour.

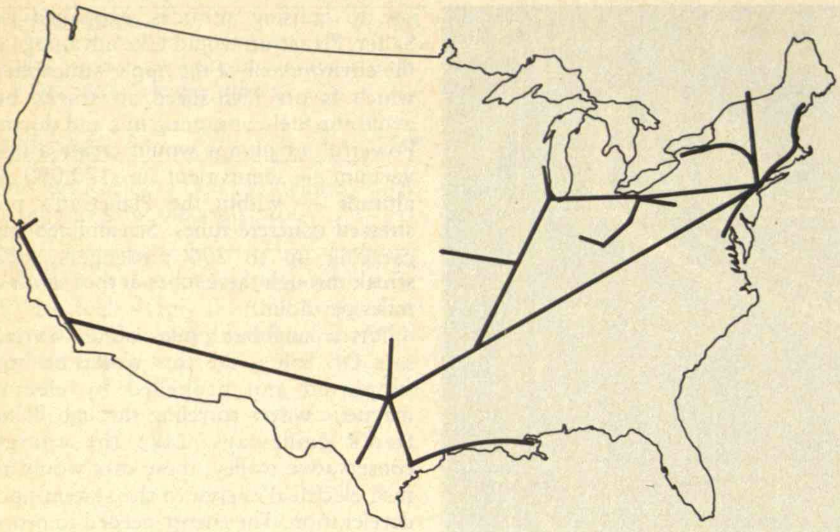
"As a surfboard rides ocean waves," says Dr. Salter, the cars would be both supported and propelled by electromagnetic waves traveling through Planetran's guideways. Like the energy-conservative trolley, these cars would return electrical energy to the system upon deceleration. The energy needed to propel one of these cars coast-to-coast would be less than $200, "only a few per cent as much energy per passenger mile as an airplane," Dr. Salter claims. However, this does not include the initial $1 billion investment in electrical energy to build the tunnel, or the cost of Planetran's vacuum systems, which Dr. Salter estimates at $320 million.

He won't guarantee how you'll feel after a 21-minute cross-country trip at 14,000 miles an hour; with an acceleration of 1 g., this is the fastest speed Planetran could achieve. At the start and finish of the journey passengers would feel up to 40 per cent heavier, but feel only a few pounds heavier at midpoint. More realistic would be a ride at 6,000 miles per hour, crossing the country in 54 minutes, and burdening the passenger with the small increment of an additional 5 per cent weight.

With interchanges at Dallas and Chicago, and subsidiary lines — to San Francisco, Boston, and Detroit — Planetran would have access to 80 per cent of the U.S. population. Although this would signify a "severe encroachment on airline service," Dr. Salter envisions that Planetran would connect with airports at these stops. Air traffic would increase to regions not served by Planetran, he says.

The 7,850 miles of tunnel would not carry just people. A four-tube configuration within the tunnel will enable two-way Planetran service and a two-way Fast Rail Service (FRS). The FRS would generate additional revenues to add to Dr. Salter's estimated $96-billion-per-year income from passenger travel, and relieve highway congestion. "Instead of trying to replace our dependence on the automobile with local rapid transit, we should augment this modern-day phenomenon," Dr.

A proposed Planetran U.S. route system map shows the major route from New York to Dallas to Los Angeles and various feeder lines. Time for a 2,450-mile non-stop trip from Los Angeles to New York: 36.5 minutes with maximum acceleration/deceleration force of 1/3 g and a maximum speed of 8,300 miles per hour; 21 minutes with maximum 1 g acceleration/deceleration and a top speed of 14,000 miles per hour (Data: RAND Corp.)



Salter says. "We must be prepared for the Los Angeles salesperson with a car trunk full of shoes who wishes to display wares in Fresno." In less time than it would take to travel by highway, the car could be sent on the FRS, and met by the salesperson who travels on Planetran.

The underground tunnels, sometimes descending as far as a mile below the surface, could also be used to house utility pipes for oil, water, and gas, and serve as the path for future communication links.

No new technology or scientific breakthroughs are needed, Dr. Salter emphasizes. Over 8,000 miles of tunnels were drilled in the 1960s alone, and present-day tunneling techniques will soon be enhanced by water jet drills, laser and particle beam devices, and the Los Alamos "Subterrene" heated tungsten probe which melts its way through hard igneous rocks. And low-cost microcomputers have solved the problem of system control: detectors every hundred feet along the Planetran guideway could correct any variance in course and speed, and adjust for tunnel movements due to earth tremors.

The cost of this underground system is equal to building a highway on the surface, says Dr. Salter. He estimates that cost at $250 billion, and urges comparison with the social costs of our present transportation system. Planetran may not be completed in the next 100 years, and Dr. Salter admits that his blueprint may never be realized. But "present travel and freight systems have proliferated without much attention toward an integrated plan for the future. We must look at what is needed or we'll have 'more of the same' in the year 2078." — *S.F.* □

Aerospace

Rough Landings for Falling Satellites

Unlike a diamond, an orbit is not necessarily forever. Of the 10,565 objects launched into earth orbit from the beginning of the space age until the end of 1977, 6,044 have returned to the atmosphere, according to N.A.S.A. Almost all orbital dropouts incinerate as they reenter the upper atmosphere, but fragments of some larger objects sometimes reach the ground. These rarities are the ones that grab headlines, particularly if they are radioactive.

Cosmos 954, the nuclear-powered Soviet satellite whose radioactive fragments fell on a remote area of Canada on January 24, made such headlines. Its mission was the radar surveillance of the oceans from a very low orbit. Cosmos 954 carried a nuclear reactor loaded with 50 kg of uranium-235 to generate the large amounts of electricity needed by its radar equipment. The satellite, not the first of its type, was apparently intended to boost into a higher "parking" orbit after completing several days of observation from the lower orbit, but never found its way to the higher orbit.

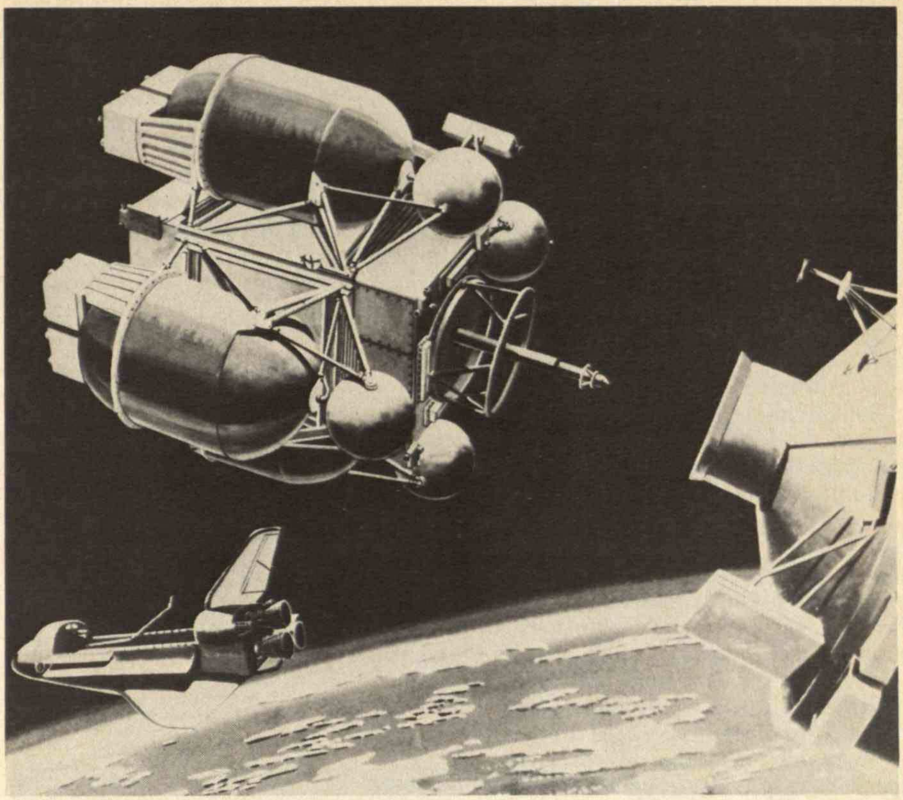
The postscript to the fall of Cosmos 954 was a brief flurry of public attention, most of which failed to evaluate critically the danger presented by the reentry of satellites. As things stand now, the danger is rather low. The chances of satellite fragments falling into a populated area is very small — oceans cover most of the earth's surface and most land areas are sparsely populated. Still, large orbital objects like Skylab that are too big to burn up completely do pose dangers. Skylab's orbit is decaying at a rapid but uncertain rate. N.A.S.A. estimates that the orbit of Skylab will decay completely sometime between March, 1979 and June, 1980, and predicts a 50-50 chance of its reentering the atmosphere before October, 1979. That date was to have marked a Space Shuttle rescue mission during which a special rocket motor and control unit called the Teleoperator would have been attached to Skylab. This unit would boost Skylab into a safe orbit or control its reentry. But the National Research Council has recommended further tests on the Shuttle's own engines, so that the date of the rescue flight is now uncertain.

When Skylab falls, N.A.S.A. predicts that it will melt and break up into fragments that will spread over an area of several thousand square miles; but no one can predict where. Until the Shuttle rescue flight, N.A.S.A. can only try to change Skylab's orientation from broadside in its orbit to one-end-forward with the space station's own engines to minimize atmospheric drag and the rate of orbital decay. N.A.S.A. reported that this maneuver was successfully accomplished in June.

The precarious state of Skylab may be partly due to N.A.S.A. miscalculations. R. Jeffrey Smith, staff writer for *Science*, reported in the April 7 issue that N.A.S.A. may have overestimated the orbital lifetime of the craft by as much as three years, and took no action to investigate the orbit until late 1977. N.A.S.A. may have ignored a National Oceanic and Atmospheric Administration prediction of greater sunspot activity in favor of its own prediction, which has proved far from correct. Greater sunspot activity results in greater atmospheric drag, and therefore faster orbital decay. Smith stated that N.A.S.A. officials apparently went with their more generous prediction of Skylab's lifetime for several political reasons, including the reassurance of a supposedly reluctant Congress to fund Teleoperator if it could not be made ready in time to rescue Skylab.

Even without political maneuvering, predicting the demise of a satellite is imprecise, at best accurate to only about 10 per cent. And even within a day of reentry, the exact place where the object will land may be unknown. For example, until a few hours before Cosmos 954 fell to earth, no one knew whether it would come down over Canada or the Pacific Ocean. The fall of a nuclear satellite is an

In this artist's rendering the Teleoperator Retrieval System (center) is poised and ready to dock with Skylab 1. Teleoperator could either rescue Skylab 1 by boosting the 85-ton station from its decaying 400-km orbit into a higher one, or could remove it from orbit. (Drawing: N.A.S.A.)



extremely rare possibility because only a handful of nuclear satellites now orbit the earth; the U.S. owns only seven and the U.S.S.R. probably has about 12. The U.S. satellites are all in stable orbits expected to last for at least a thousand years; by that time much of their radioactivity will have fallen to low levels. Conventional solar-rechargeable batteries power most instruments used in space. Nuclear batteries are needed only by probes launched into deep space where there is not enough sunlight, and by satellites that must be "hardened" against damage or detection, according to Kosta Tsipis of M.I.T. and Thomas Kerr of N.A.S.A.

All but one U.S. nuclear satellite carries a radioisotope thermal generator (RTG), in which the heat of decaying plutonium-238 is converted into electricity by thermocouples. RTGs supply between 30 and 500 watts, says Dr. Kerr — enough to meet all U.S. satellite power needs. Only the U.S. SNAP 10A satellite carries a nuclear reactor as a small experimental power system. However, the Russians' need for greater power apparently led them to use larger reactors like the one in Cosmos 954.

No formal federal regulations cover nuclear power sources in space, says Dr. Kerr, but an interagency group that involves N.A.S.A., the Department of Energy, and the Department of Defense has developed some informal guidelines covering both RTGs and reactors. Until 1965, these interagency guidelines required that the plutonium-carrying RTGs be designed to burn up completely in the upper atmosphere upon reentry. It was thought that if the products of the plutonium burn-up were dispersed evenly over the globe, the exposure to any one area would be minimal. In 1964 an RTG-carrying satellite did burn up. According to Theodore Dobry, Chief of the Safety and Fuels Branch of the Department of Energy, no measurable quantities of plutonium reached the earth's surface; nevertheless, in 1965 the standards were changed: now RTG plutonium capsules are to land on earth intact and recoverable.

However, U.S. reactors are designed to burn up when they hit the atmosphere — a reactor core that fell intact might place highly-enriched uranium in unfriendly hands. The U^{235} in a new reactor is not highly radioactive; but nuclear fission products that appear after reactor startup are very dangerous. Although the U.S. is not now launching satellites equipped with reactors, the guidelines further specify that satellite reactors should be started only after the satellite achieves a safe, long-lived parking orbit.

The basis for assigning liability for damages caused by hazardous reentry is far from firm. For example, the Russians were fully liable for clean-up costs for Cosmos 954 under the terms of existing treaties, says George Robinson, a space law expert and General Counsel for the Smithsonian Institution. But Canada found it difficult to extract payment from the U.S.S.R. Indeed, "the Soviets didn't want the matter discussed at all," reports N.A.S.A. General Counsel Neil Hosenball, who attended the recent U.N. Space Committee meetings in Geneva.

A number of treaties cover liability for space accidents, according to N.A.S.A. lawyer Pierre Hartman. But as with many legal agreements, says Mr. Hartman, interpretation of pertinent clauses in real situations can vary greatly. Not surprisingly, Canada, with backing from the U.S. and other nations, is seeking additional agreements through subcommittees of the U.N. Space Committee to require publication of safety analyses for nuclear power plants in space, and notification and assistance by the launching party in case of an accident. The plan also calls for a working group to study current agreements and to recommend new ones.

While the U.S. relies very little on nuclear power aboard satellites, Mr. Hosenball said that the U.S. opposed a recent Swedish proposal for a moratorium on all nuclear power sources in space. Why the opposition? Possibly military space planners may wish to use reactors if war takes to orbit — to replace solar panels, which are large and therefore easily detected and destroyed. Also nuclear power plants may be used in orbiting space colonies.

In the future the Space Shuttle could be used to retrieve or repair satellites in danger of reentry. Dr. Tsipis foresees a day when satellites will be routinely repaired by orbiting servicing crews. Nevertheless, the Shuttle has created a dispute even before its first launch. The Soviet Union has served notice that the Shuttle will have to be included in discussions of so-called "killer" satellites, ostensibly because the U.S. ability to approach and service our satellites could be used against their "killer" satellites as well.

One wonders what might have happened if the U.S. had had the Shuttle when Cosmos 954 was falling. What would have been the Canadian reaction if the U.S. did nothing to prevent the satellite's reentry for fear of disturbing U.S.-Soviet relations? Only a few more such scenarios would keep space lawyers busy for quite a number of years. *— Mark James* □

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Technology Frays the Thread of Peace

The U.S. has traditionally relied on a triple-threat system to dissuade its enemies from nuclear destruction: land-based intercontinental missiles, bomber aircraft capable of intercontinental missions, and nuclear-powered long-range submarines. The versatility of this force, which is essentially matched by similar Soviet capabilities, means that each nation is deterred from initiating a strike against the other by the assurance of retaliation in equally horrendous kind.

But this thread that restrains the two superpowers from inflicting nuclear holocaust upon the world — and in some sense dissuading them from further escalation of the nuclear arms race — is thin at best and almost certain to weaken in the future, say four members of the M.I.T. community in the first report from a new Program in Science and Technology for International Security. They are convinced, they say, that "new technological improvements will create threats to the national security of the U.S. and U.S.S.R. more rapidly than the present international political climate permits the conclusion of agreements constraining weapons."

As a case in point, they examine in detail the arms control implications of a proposed new U.S. land-based intercontinental ballistic missile designated MX (missile experimental) now being planned to replace the Minuteman. *(See "MX: $30 Billion for Parity?" May, 1978, p. 23)* The new weapon, for whose development some $481 million has already been appropriated, would have a payload of over 9,000 pounds (compared with 2,500 pounds of the Minuteman III); it would thus carry at least nine multiple warheads compared with the Minuteman's three, and it would be vastly more accurate than the Minuteman.

The MX is a response to similar escalation of land-based power by the U.S.S.R., which has "developed, tested, and begun deploying a new class of I.C.B.M.s with improved accuracy, more warheads, and greater yield," says the P.S.T.I.S. report. By 1985 the Soviets could deploy some 6,000 such warheads suitable for an attack against our Minutemen, which lie in 1,000 protected silos across our northern boundaries. That gives a striking power of six warheads against each Minuteman silo — hardly the parity on which hangs the thread of peace. "By 1990," says the report, "the Soviet Union could in theory be capable of destroying the majority of Minutemen in their silos."

The MX program designed to meet this threat may cost as much as $30 billion dollars — nearly $18 million in 1976 dollars. That includes hiding the new missiles in tunnels through which they can be moved secretly, so that the enemy cannot know precisely where it must strike to destroy them. But that concept of hiding our missiles by making them mobile under ground creates "insuperable arms control problems" because it renders all forms of inspection impossible, says the P.S.T.I.S. report.

To slow or halt these developments, the four M.I.T. arms control experts — Professor Bernard T. Feld, Michael Callaham, E. Hadjimichael, and Kosta M. Tsipis — call for a prompt U.S.-U.S.S.R. agreement "to limit drastically the testing of long-range missiles." Though they admit that this could not halt completely development of new weapons, it would slow such developments significantly and turn the emphasis to deterrence instead of destruction. — *J.M.* □

Energy

The Uranium Crunch

U.S. nuclear-powered reactors last year required enriched uranium from 12,000 short tons of uranium oxide (U_3O_8). By 1980 the requirement will be for perhaps 45,000 to 60,000 tons — bringing the cumulative requirement since the beginning of nuclear power to 400,000 to 500,000 tons. If the U.S. is to fill these requirements, it must sharply increase its rate of successful uranium exploration. Without new resources, Professor Leon T. Silver of the California Institute of Technology told the American Association for the Advancement of Science last winter, uranium supply and demand curves will cross sometime between 1982 and 1990. Reactors may shut down for lack of fuel soon thereafter.

Depending on the future growth of the nuclear power industry, Professor Silver estimates the cumulative requirements by 2000 to be 1.0 to 1.3 million tons. The foreign demand occasioned by President Carter's ban on plutonium recycle and export could boost this figure.

Cumulative U.S. uranium production now stands at 310,000 tons, so production in the next 30 years must at least triple that of the last 30. Already the best known uranium deposits are depleted, and a few are exhausted. Can enough undiscovered new uranium be found and mined to meet the projected demand?

The Department of Energy estimates that reserves of 680,000 tons of U_3O_8 can be produced profitably if uranium oxide sells for $30/pound; 840,000 tons could be produced if the price is $50/pound. (That's a modest 24-per-cent increase in reserves for a 67-per-cent increase in price, suggesting that the price of uranium has nowhere to go but up; on the other hand, past variations in the cost of nuclear fuel have had little influence on the cost of nuclear power.)

The problem for the 1980s will be to bring most of these known uranium reserves into production and at the same time bring into production some resources not yet discovered. That's a tall order. Discovery does not lead to immediate production; to produce 40,000 tons of new U_3O_8 by 1990, the exploration industry must turn up 400,000 tons in new discoveries (or new confirmation of reserves) by 1985. The goals are not impossible, says Professor Silver, but they do represent "an annual level of success rarely sustained in the past." To reach them, the industry will need all the help it can get — including significant new investments in geological research on how uranium ore deposits were actually formed. — *J.M.* □

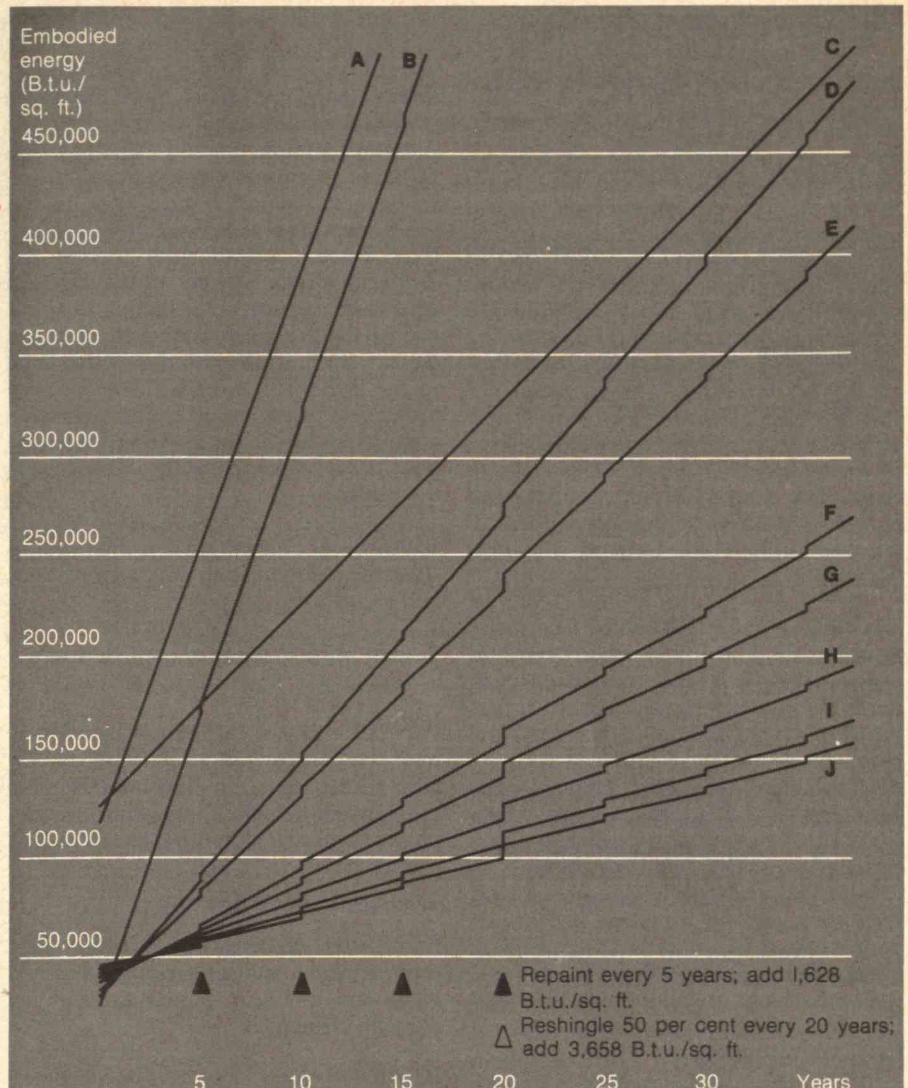
Architecture for an Energy Crisis

The double-hung, single-glazed, wood-framed window in a typical house costs 15,430 B.t.u.s of energy per square foot of opening to make. That figure includes the energy used to cut down, transport, and mill the tree, to dig the sand and make the glass, to assemble the components into a window unit, and to deliver and install the window in the frame of a house. If the house is in a climate like that of New York City, the window will be responsible for an annual heating demand 131,477 B.t.u.s greater than that of a square foot of uninsulated wall surrounding it.

If the window is double-glazed, with the two panes of glass spaced one-quarter inch apart, the energy "embodied" in its construction and installation is nearly doubled: 30,860 B.t.u.s per square foot; but the annual excess energy consumption is only 75,628 B.t.u.s. At current fuel prices, such a double-glazed window will pay for itself through fuel savings in less than half a heating season; over a 20-year period it will save the nation 1.1 million B.t.u.s.

marked copy to
Prof. Bruce Hannon
Urbana, Illinois

Each line on this graph represents the energy demand of a particular group of materials used in the exterior walls of a hypothetical wood stud frame house in New York City, according to the University of Illinois' Energy Input/Output Model. Energy "embodied" in making and assembling 1 sq. ft. of each wall type is shown at year 0, to which each is added the annual heat loss of 1 sq. ft. of wall, and for shingled exterior walls, the energy cost of periodic maintenance.



An immense quantity of unique data, including those just iterated, relating building materials and styles to energy consumption has recently come from the computerized Energy Input/Output Model at the University of Illinois Center for Advanced Computation, whose staff worked in collaboration with Richard G. Stein and Associates, a New York architectural firm long involved in studying the implications of the "energy crisis" for building design and construction. Mr. Stein says the new data will give architects the basis for a more rational philosophy of building design and may soon return us to an era of regional architectural styles such as prevailed 200 years ago — pueblos in the hot, dry southwest, brownstones in cold, wet New York, and porches and pavilions in tropical, humid Galveston.

Among different building categories, laboratories on average take the most energy to build, requiring over 2 million B.t.u.s per square foot of finished space, including furnishings and equipment. Hospital buildings are next, at 1.7 million B.t.u.s per square foot; over 30 per cent of this is devoted to the specialty equipment and systems required for health care. Farm buildings are the least costly of energy to build — just under 150,000 B.t.u.s per square foot. Single-family residences come in at a low 700,000 B.t.u.s per square foot — mostly because they rely on wood, which is among the least energy-intensive of building materials.

But within building categories, designers and builders can influence energy investments considerably. Reinforced concrete construction represents 60 per cent less embodied energy than conventional steel construction for floors in high-rise office buildings, for example. Though calculations are not yet complete, analysts think that a comparable difference carries through to the entire high-rise structure, so that — as far as energy embodiment is concerned — concrete is the system of choice. Another example: a brick-veneered wall in typical residential construction represents four or five times as much energy as a shingled wall, because brick is highly energy-intensive compared with wood.

The embodied energy is only a fraction of the energy consumed in the total life of a building, and the latter is the really important figure. For example, compare two 1,500-square-foot one-family houses of conventional design and construction. One house has 3.5 inches of insulation in walls and roof, single glazing, and an embodied energy of 168.8 million B.t.u.s, considering all the materials and the costs of putting them in place; in New York City, 67.3 million B.t.u.s would be needed each year to replace heat lost through thermal transmission by such a house. The other house has 5.5 inches of insulation and double glazing, and an embodied energy of 178.8 million B.t.u.s in materials and construction. But it consumes only 35.2 million B.t.u.s annually to replace heat lost through walls and roof to the outdoors. Both houses are assumed to use 41.8 million B.t.u.s a year to counteract heat lost through infiltration and the opening of doors and windows. The final accounting: the first house represents a total 20-year commitment of 2,351 million B.t.u.s; the second, only 1,719 million.

Check & Marked Copy

Adventures on a Leisurely Trip from Aardvark to Zymurgy

Allan J. Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics and Coordinator of Computer Activities in the Mathematics Department at York College of the City University of New York. Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y., 11451.

Your editor is very pleased to report that he is now an (unpaid) television "star." In keeping with my high journalistic standards (I "allow" "Puzzle Corner" to appear only in *Technology Review*), my television debut (and finale) was with the best show on television, "Nova." The crew from WGBH came to the World Computer Chess Championship to film a segment for "The Mind Machines," an account of artificial intelligence. I was there, too, and for a fleeting instant our paths crossed.

Enough said; let's get down to business.

Our backlogs are all quite large except for chess problems, of which there is a near-critical shortage.

Problems

JUN/JUL 1 We start with a bridge problem from William Butler:

♠ 7 3
♥ Q J
♦ 5 2
♣ A K 5 3 2

♠ A Q 2
♥ A K 7 6 5 4
♦ A Q
♣ J 6

With South the declarer at six hearts, West leads the ♥10. South thinks a moment or two and plays a heart from dummy. East discards a diamond. What is the best play to make six hearts? If possible, supply the probability of success.

JUN/JUL 2 Our second problem, from Frank Rubin, concerns a leisurely effort to avoid colliding with a train:

I am walking the 25 miles from Aardvark to Zymurgy. Part of the way there, I begin to cross a railroad bridge. When I have gone three miles along the bridge, I hear a diesel train leaving the Aardvark station. I could exactly escape the train by running to either end of the bridge. But instead I cross over to the other track and walk four miles further. Now I see a steam train leaving the Zymurgy station on my track. Again, I could exactly escape by running to either end of the bridge. But instead, since the diesel train has just passed, I switch back to the first track. I reach the end of the bridge just as the steam train reaches the start of the bridge (in my direction). One hour later, I reach Zymurgy. How long is the bridge?

JUN/JUL 3 Eugene Sard wants you to solve the following pair of equations for x and y:

$$1 - xy = x + y^2$$

$$1 - xy = y + x^2$$

JUN/JUL 4 Jeff Kenton must be a lonely man. He has invited all *Technology Review* readers to call him at home. Unfortunately, all he will tell us about his telephone number is that it has the following property:

$$\text{myphone} = (my)^*(hy)^*(p)^4$$

Each letter represents a different digit (none repeats), and neither of the first two digits can be 0 or 1 (it's a telephone number, remember).

JUN/JUL 5 John Gray asks us a geometric construction problem:
Given a line and two points on one side of the line, construct the smaller circle which passes through the points and is tangent to the line.

Speed Department

JUN/JUL SD 1 Harvey Elentuck knows some pairs of "crazy fractions" — ones that add the same way as poor algebra students. The first type satisfy:

$$a/b + c/d = (a + c)/(b + d).$$

For example, $-4/12 + 1/6 = -3/18$, and $25/10 + -81/18 = -56/28$.
The second type satisfy

$$a/b - c/d = (a - c)/(b - d).$$

For example, $15/10 - 16/8 = -1/2$.

What conditions on a, b, c, and d guarantee a pair of the first type? The second type?

JUN/JUL SD 2 Winthrop Leeds has a "non-algebraic" way to solve the following problem:
A man starts rowing steadily upstream from point A on a certain river. At point B exactly one mile upstream he notices an odd-shaped log floating by. He continues to row for an hour more before turning around and rowing back downstream. When he arrives back at his starting point A, he observes that he has just caught up with the floating log. What is the velocity of the river?

Solutions

FEB 1 Place one White King, two White Rooks, and one Black King so that White, who is to move, can mate with any of four moves.

Hal Moeller supplied us with the following solution:
White King at K1 (unmoved), White Rook at KR1 (unmoved), White Rook at QB2, and Black King at KR8. White's four mating moves are K to Q2, K to K2, K to KB2, and castles.

Also solved by Lindsay Faunt, Steven Ross, Peter Siczenicz, Jay Anderson, William Butler, Eric Piehl, S. D. Turner, Abe Schwartz, James Shearer, and the proposer, Steven Grant.

FEB 2 When does $[\sqrt{n}]$ divide n where [ ] is the floor or greatest integer function? More generally, when does $[\sqrt[k]{n}]$ divide n?

The following solution is from Naomi Markovitz:

If n is a perfect square, obviously $[\sqrt{n}]$ divides n. Otherwise we want $ab = n$:

$$a < \sqrt{n} < (a + 1)$$

$$a^2 < n < (a + 1)^2$$

$a < n/a < (a + 2 + 1/a)$. This last is

$a < b < (a + 2 + 1/a)$. Hence b is no more than 2 greater than a. Thus n can be expressed as $a(a + 1)$ or $a(a + 2)$ as well as a^2. In the general case we want $ab = n$:

$$a \le n < (a + 1)$$

$$a^k \le n < (a + 1)^k$$

$$a^{k-1} \le n/a < (a + 1)^k/a$$

$$a^{k-1} \le b < (a + 1)^k/a.$$

Also solved by William Butler, Winslow Hartford, and Jerry Griggs.

FEB 3 Given an n-by-n checkerboard and n^2 checkers of n different colors, and given that there are n checkers of each color, is it possible to arrange all the n^2 checkers on the board so that no two checkers of the

1	2	3	4	5
3	4	5	1	2
5	1	2	3	4
2	3	4	5	1
4	5	1	2	3

1	2	3	4	5	6	7
3	4	5	6	7	1	2
5	6	7	1	2	3	4
7	1	2	3	4	5	6
2	3	4	5	6	7	1
4	5	6	7	1	2	3
6	7	1	2	3	4	5

same color lie in the same row, column, or diagonal? (By diagonal is meant *all* the diagonals, not just the two main diagonals.)

Everyone agrees that this is impossible for n even. Harry Zaremba gives us an algorithm for two-thirds of the odd integers; since by exhaustive search one can show that no solution is possible for n = 3 (he predicts this), his algorithm may be the best possible. My feeling is that the problem remains not completely solved (n even and one-third of n odd) and may appear as an NS-problem in the 1980s. (An interesting variant of this problem has just been posed by Paul Monsky, a professor of mine at Brandeis, in the American Mathematical Monthly.) Mr. Zaremba's comments follow:

Solutions are possible for all odd values of n such that $n \equiv 1 \pmod 3$ or $n \equiv 2 \pmod 3$. Arrangements for n = 5 and n = 7 are shown below, in which the different tones are denoted by distinct integers. Solutions for even values of n are not possible. Arrangements can be developed easily by means of the following procedure:

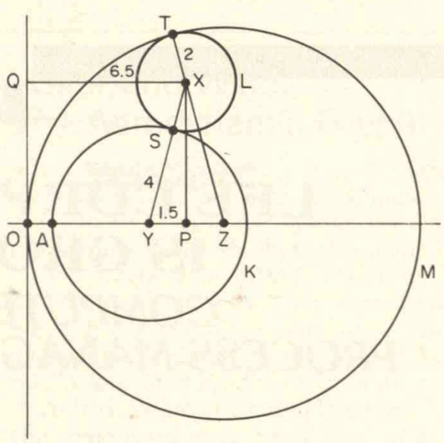
1. In the first column, place the consecutive odd integers in order followed by the consecutive even integers.
2. Arrange the integers in consecutive order in each row starting from the integer in the first column progressively to the largest integer, and resume the consecutive order with the remaining integers.

Many other patterns are possible. The sequence of integers in the main diagonal downward to the right offers a clue to why odd values of n divisible by 3 cannot be arranged to meet the requirements.

Also solved by Jay Anderson, Eric Piehl, Abe Schwartz, and the proposer, Sheldon Razin.

FEB 4 In the figure, circle L is tangent to circles K and M, and the shortest distance from its center to the tangent at 0 is 6.5 inches. If the distance between tangents at 0 and A is 1 inch, and the radii of circles K and L are 4 and 2 inches, respectively, what is the radius of circle M? What is the locus of the centers of all circles which are tangent to both circles K and M?

The following solution is from Shirley Wilson:



Let X, Y, and Z be the centers of circles L, K, and M, respectively. Let S and T be the points where circle L is tangent to circles K and M, respectively. Let P and Q be the projections of X onto the diameter of M and the tangent at 0, respectively.

Since $|QX| = 6.5$, $|OA| = 1$, $|AY| = 4$, and $|OP| = |QX|$, $|YP| = 1.5$. The segment XY is between the centers of L and K, and hence, $|XY| = 2 + 4 = 6$. Applying the Pythagorean Theorem to ΔXPY, $|PX|^2 = 36 - 2.25 = 33.75$.

The radius of M is $|TZ| = |TX| + |XZ| = 2 + |XZ|$. The radius of M is also $|OZ| = |OP| + |PZ| = 6.5 + |PZ|$. Therefore, $2 + |XZ| = 6.5 + |PZ|$, or $|XZ| = 4.5 + |PZ|$.

Using ΔXPZ, $|PX|^2 + |PZ|^2 = |XZ|^2$. Substituting, one finds that $|PZ| = 1.5$. Hence the radius of M is $6.5 + 1.5 = 8$.

Now let L be a circle tangent to circles K and M such that the radius of L is r. Using the notation above, $|XY| + |XZ| = (4 + r) + (8 - r) = 12$. Hence, X traces an ellipse with foci at Y and Z, the centers of K and M, and with a major axis of length 12. If 0 is the origin of a coordinate system, the foci are Y = (5,0) and Z = (8,0), so that the center of the ellipse is at P = (6.5,0). The minor axis is of length $2(33.75)^{1/2}$ since in the previous problem, PX was perpendicular to OP and $|PX|^2 = 33.75$. Hence, the equation of the ellipse would be

$$(x - 6.5)^2/36 + y^2/33.75 = 1.$$

Also solved by Jay Anderson, William Butler, Calvin Simmons, Naomi Markovitz, Winslow Hartford, W. C. Kenner, John Rule, Sheldon Katz, Harold Heins, Norman Wickstrand, Emmet Duffy, James Shearer, and the proposer, Harry Zaremba.

FEB 5 "Tick Tack Math" has 52 playing cards numbered 1 to 40 with 1 to 12 repeated. The mechanics of the game involve using two-card mathematical combinations to equal upturned single cards from the same deck. Addition, subtraction, division, and multiplication are all acceptable combinations. A single card that matches an upturned card can also be played. The question is: Ignoring knowledge of other upturned, played, or held cards, how many practical ways (including permutations) are there of making each number? "Practical" is meant to eliminate from the solution such combinations as 2 − 1 = 1 which, while mathematically correct, waste a card.

There seems to be some controversy as to whether or not to count 13 − 12 as two solutions (using the two different 12s in the deck) or as one solution. My guess is that the former was intended, but I am not sure; the proposer, Richard J. Alden, agrees with me. Of course, this would mean that 5 − 4 yields four solutions. Avi Ornstein holds the view that 13 − 12 is only one solution, and his answer is shown in the box on the next page. Naomi Markovitz has the satisfaction of knowing that she agrees with me. However, she neglected to consider the possibility of solutions like 4 which involve only one number (i.e., no arithmetic operators). No one considered the possibility of more than one operator — a good thing (see **PERM 2** for an idea of what can happen). Anyone desiring a copy of "Tick Tack Math" should write to Richard J. Alden, 1182 Sesame, Sunnyvale, Calif. 94087.

Value	Identity	Addition	Subtraction	Multiplication	Division	Total
1	1		38		11	50
2	1	1	37		18	57
3	1	1	36		11	49
4	1	2	35	1	8	47
5	1	2	34		6	43
6	1	3	33	1	4	42
7	1	3	32		4	40
8	1	4	31	1	4	41
9	1	4	30	1	3	39
10	1	5	29	1	3	39
11	1	5	28		2	36
12	1	6	27	2	2	38
13		6	26		2	34
14		7	25	1	1	34
15		7	24	1	1	33
16		8	23	2	1	34
17		8	22		1	31
18		9	21	2	1	33
19		9	20		1	30
20		10	19	2	1	32
21		10	19	1		30
22		11	18	1		30
23		11	17			28
24		12	16	3		31
25		12	15	1		28
26		12	14	1		27
27		13	13	1		27
28		13	12	2		27
29		14	11			25
30		14	10	2		26
31		15	9			24
32		15	8	2		25
33		16	7	1		24
34		16	6	1		23
35		17	5	1		23
36		17	4	4		25
37		18	3			21
38		18	2	1		21
39		19	1			20
40		19		3		22
						1,289

Better Late Than Never

Y1977 Alan Katzenstein and Irene Greif correct two misprints, namely

$22 = [(9 - 1) + 7] + 7$
$81 = 9^{**}(1 + 7/7).$

They also give two improvements which have the digits in the preferred order and still require the same number of operators as the published solutions:

$16 = (1 + 9/7)^*7$
$50 = (1^{**}9) + (7^*7).$

1977 O/N2 Eric Jamin was the proposer; Emmet Duffy and John Rule have responded.

1978 JAN 3 Ely Stern, Thomas Sico, Bob Franzosa, Woodruff Sullivan, and the team of Chaplick Chaplick McDonough and Lennox have responded.

JAN 4 John Prussing has responded.

PERM 2 Up to 130, we need solutions for 87, 93, and 107. The object is to create these numbers using exactly four 4s and the minimal number of arithmetic operators — ! (factorial), √ (square root), and . (decimal point). I have received responses from C. Little, G. Ropes, H. Goldman, M. Gasser, H. Zaremba, F. Rubin, and H. Hazard. Two improvements and some new answers (up to 170) follow; more will be given in December.

Let $Z = \sqrt{\sqrt{\sqrt{.\sqrt{4^{**}(-4!)}}}} = 125$

$X = \sqrt{\sqrt{\sqrt{4^{**}(4!)}}} = 64$

$106 = (44/.4)-4$	$152 = 44^*4 - 4!$
$115 = (44 + \sqrt{4})/.4$	$153 = Z + 4! + 4$
$134 = 44/.4 + 4!$	$154 = (4!/.4)/.4 + 4$
$135 = Z + 4/.4$	$155 = (4!/.4 + \sqrt{4})/.4$
$136 = (4! + 4)^*4 + 4!$	$156 = (4 + \sqrt{4})!/4 - 4!$
$137 = Z + 4!/\sqrt{4}$	$157 =$
$138 = (4!^*4! - 4!)/4$	$158 = (X/.4) - \sqrt{4}$
$139 = (4! + 4 - .\sqrt{4})/(.\sqrt{4})$	$159 = (X - .4)/.4$
$140 = [(4!)/.4 - 4]/.4$	$160 = 4^{**}4 - 4!^*4$
$141 = Z + 4^*4$	$161 = (X + .4)/.4$
$142 = 4!^*4!/4 - \sqrt{4}$	$162 = X/.4 + \sqrt{4}$
$143 = (4!^*4! - 4)/4$	$163 =$
$144 = (4 + \sqrt{4})! - 4!^*4!$	$164 = 44 + (\sqrt{4}/.4)!$
$145 = (4!/.4 - \sqrt{4})/.4$	$165 = (X + \sqrt{4})/.4$
$146 = (4!/.4)/.4 - 4$	$166 =$
$147 = Z + 4! - \sqrt{4}$	$167 =$
$148 = (4!/.4)/.4 - \sqrt{4}$	$168 = (4!^*4!)/4 + 4!$
$149 = (4!/.4 - .4)/.4$	$169 = \sqrt{(4! + \sqrt{4})}/\sqrt{4^{**}4}$
$150 = \sqrt{4^*4!/.4/.4}$	$170 = (44 + 4!)/.4$
$151 = (4!/.4 + .4)/.4$	

Proposers' Solutions to Speed Problems

JUNE SD 1 $b^2/d^2 = a/c$; $d^2/(2bd - b^2) = c/a$.

JUNE SD 2 Instead of following a fairly straightforward approach of setting up the critical equation, from which the rowing speed s drops out, the following mental reasoning will provide the answer: From B the man rows upstream in one hour the distance $(s - r)$ miles, where r is the speed of the river. From turnaround the man rows downstream *in one hour* $(s + r)$ miles. The difference is 2r miles, which is exactly the distance the log has floated in the two hours since it was first sighted at B. Thus the man has caught up with the log. To make this catch-up point one mile below B at A, $2r = 1$; and $r = 1/2$ mi./hr.

Preston Vorlicek, '79, All-American swimmer who is a student in aeronautics and astronautics, wanted to know how to hold his hands in the butterfly stroke. So he combined his avocation with his intended vocation by making plaster casts representing four different possible hand positions and testing them in an M.I.T. wind tunnel. (Photo: Calvin Campbell)

When a Cutting Tool Stops Cutting

The owner of a metalworking shop is confronted by a dilemma: as a metal-cutting tool is used, it gradually — and unpredictably, as it turns out — wears out. At some point in the life such a tool it becomes so inefficient that it should be retired: a new tool will do the job enough faster and better to justify its cost.

Many different ways of sensing tool wear — including some ingenious ones — have been tried over the years: the changing shape of the cutting face, the changing shape of the workpiece it produces, the size of the tool as indicated by its electrical resistance, the increasing force needed to cause the tool to cut, the temperature of the tool after a specified cutting operation, the number of tool particles (they are radioactive if the tool has been irradiated with high-energy x-rays) among the work chips.

None works very well, and tool life remains an unpredictable frustration for many operators. Now Professor Nathan H. Cook and several colleagues in the M.I.T. Department of Mechanical Engineering have patented a new solution — a "micro-isotope" implantation.

A small pellet of a radioactive isotope of the tool metal is implanted at a prescribed distance from the cutting edge of the tool as it is made. When the tool has worn down to the level of the pellet, the low-level radioactivity of the pellet begins to show up in the work chips. The shop foreman next testing for radioactivity thus discovers it's time to change tools.

Isotopes of hafnium, ruthenium, and tungsten seem best. The method has been proved by sensing the wear of high-speed drills and turning tools under laboratory conditions, and now tests are going forward in industrial settings.

If the "micro-isotope" system works with tools, Professor Cook thinks it may also be successful for sensing wear in forging dies, punches, and other metal-forming equipment. — *J.M.* □

New Richness for a Technological Age

Look around you: our cities are unaesthetic wastelands, our air and water are dirtied, our space is disjointed and constricted, our people lifeless, uncommunicating, and unhappy — "sensory degradation," Professor Gyorgy Kepes calls it.

Instead of freeing us to understand the richness of nature and the whole self, technology has somehow enslaved us, surrounded us with an ugly, infinitely complex and interdependent world of which engineers have little understanding and no control.

Where technology has failed, however, art may succeed, thinks Professor Kepes, who has taught art and design for 30 years while observing and chronicling the unique visual images inherent in science and technology. In all that time, he told an M.I.T. audience this spring as a retrospective of his work opened at the Institute, his goal has been to achieve "new ideas, new vistas for the environment — creative, artistic forms which would give to humans a sense of richness" they now lack.

The greatest challenge of all is to express today's interdependence — "everything one does has echoes in distant places" — in visual, aesthetic terms — "the chance literally to create a new community." — *J.M.* □

Water and Wind: The Aerodynamic Flipper

When Preston Vorlicek, '79, took sixth place in the N.C.A.A. national swimming championships early this spring, he was capitalizing on superb physical condition — and insight from an M.I.T. wind tunnel. The wind tunnel was not an unusual place for Preston's work: he is an aeronautical engineering major, and he was looking for a hand most like a wing.

Vorlicek swims the butterfly stroke. If you could watch from below as a swimmer performs that stroke, you would see the crude outline of a butterfly's wings traced by the swimmer's hands. As the stroke begins, the hands slice into the water and immediately sweep down and out to make the large crescents of the wings' outline. An inward pull of the hands until they almost touch under the swimmer's chest closes the crescents; then another outward thrust forms the curve of the wings's tail. The swimmer's arms, now fully extended behind him, break from the water and return over the swimmer's head for the next stroke.

The force of the arms is concentrated in pushing and pulling the hands outward and inward. These rapid, sideways motions create lift — much as the wings of an airplane do when moving through air. The wing has an upward lift that enables flight; the hands with palms at a small angle from the direction of motion produce lift that propels the swimmer forward. The hands thus play a crucial role in giving the swimmer speed in the water.

How should the hands be used to give a swimmer most lift and power? Mr. Vorlicek knew how to find the answer: he knew that a body moving through water acts much as it does when moving in any other fluid — liquid or gas. So the wind tunnel's blown air could simulate the flow of water against the swimmer's hand.

Preston worked with a small wind tunnel and four life-size plaster casts of hands held in positions that swimming coaches feel are the most effective in the water. In one case the fingers were bent slightly to form a shallow cup; in all others, the hands and fingers were straight. In one case, the fingers and thumb were held tightly together; in another, the thumb and small fourth finger were spread out a bit with the three middle fingers still tightly held; in the fourth, all the fingers and thumb were spread slightly.

One at a time, these plaster casts were mounted on a special balance which measured their lift and drag when blasted with 50-m.p.h. winds; such high speed was needed to simulate the effects of water at much slower velocities.

The hands witn the straight, closely-

marked copy to Prof. Rae Goodsell

held fingers were the most efficient in producing lift. The hand with all fingers held tightly was the most efficient when moving toward the swimmer's body, the hand with the thumb and fourth finger slightly spread more efficient when moving away from the body. As the models were rotated in the air stream, Preston found that an angle of 25° between the palm and the wind produced the greatest lift.

Were the results surprising? "A little," says Preston. "Although no one was sure which of the hands would be the most effective, Coach [John A.] Benedick's [M.I.T. swimming coach] choice turned out to be the most inefficient hand of my four." How much difference does hand position make? Mr. Vorlicek is quick to point out no one factor will assure victory; championship swimming is strength, style, and a bit of luck. On the other hand . . .

"In the 1972 Olympics, Gunnar Larson beat Tim McKee for the gold medal by 0.002 second. My results can increase the efficiency of a swimmer by a tiny amount; and, as you can see, in swimming you need all the help you can get." —*Roland B. Thompson, M.I.T. '80* ☐

On the Genesis of Muscle

The discovery several years ago that a protein called actin occurred in a variety of animal cells was puzzling. Actin was known to play an important part in muscle contraction; what was it doing in non-muscle cells?

The answer is that there are several different actins, made by different genes. The finding is regarded by three M.I.T. scientists — Dr. Robert V. Storti, Professor Alexander Rich, and Donald M. Coen — as potentially important as a clue to the genesis of muscle — one aspect of the miracle by which a single cell gives birth to many kinds of tissue. ☐

Seven Billion Cells per Liter

M.I.T.'s Cell Culture Center is now growing chick embryo and human tissue cells on tiny beads of dextran, testing a new culture medium which makes possible remarkable increases in cell growth rate.

The new method promises a dramatic decrease in cost — a reduction on the order of 80 to 90 per cent in the expense of growing animal cells, according to three members of the Department of Nutrition and Food Science, Dr. David W. Levine, Professor Daniel I. C. Wang, and Professor William G. Thilly.

Dextran is formed into microspheres about 150 microns in diameter; these beads are suspended in a stirred tank, where they provide a large surface area for cell growth. Using standard culture media, the scientists obtained concentrations of more than 7.6 million cells per milliliter. ☐

X-Rays from Cassiopeia

Seven years ago, the primitive x-ray detectors aboard SAS-1 (Small Astronomy Satellite) found a pulsing x-ray source in Cassiopeia; it was one of the first of a new class of radiators — a pulsar. Several months later it disappeared as an x-ray source; and so the M.I.T. astronomers manning the SAS-1 experiments listed it as "highly variable" and "transient."

Early this year the x-ray source in Cassiopeia "turned on" again, emitting a strong pulse of x-rays every 3.6 seconds. The discovery was made by SAS-3, now in orbit for M.I.T. astronomy experiments, and confirmed by scientists at the Goddard Space Flight Center using a monitor aboard Britain's Ariel 5 satellite. It's not clear whether the x-rays come from a visible or invisible star in Cassiopeia, but Professor Saul A. Rappaport of the M.I.T. Center for Space Research thinks the new episode will give him and his colleagues a good chance to learn about the evolutionary history of transient pulsars, which he says is now "a big mystery" to astrophysicists. ☐

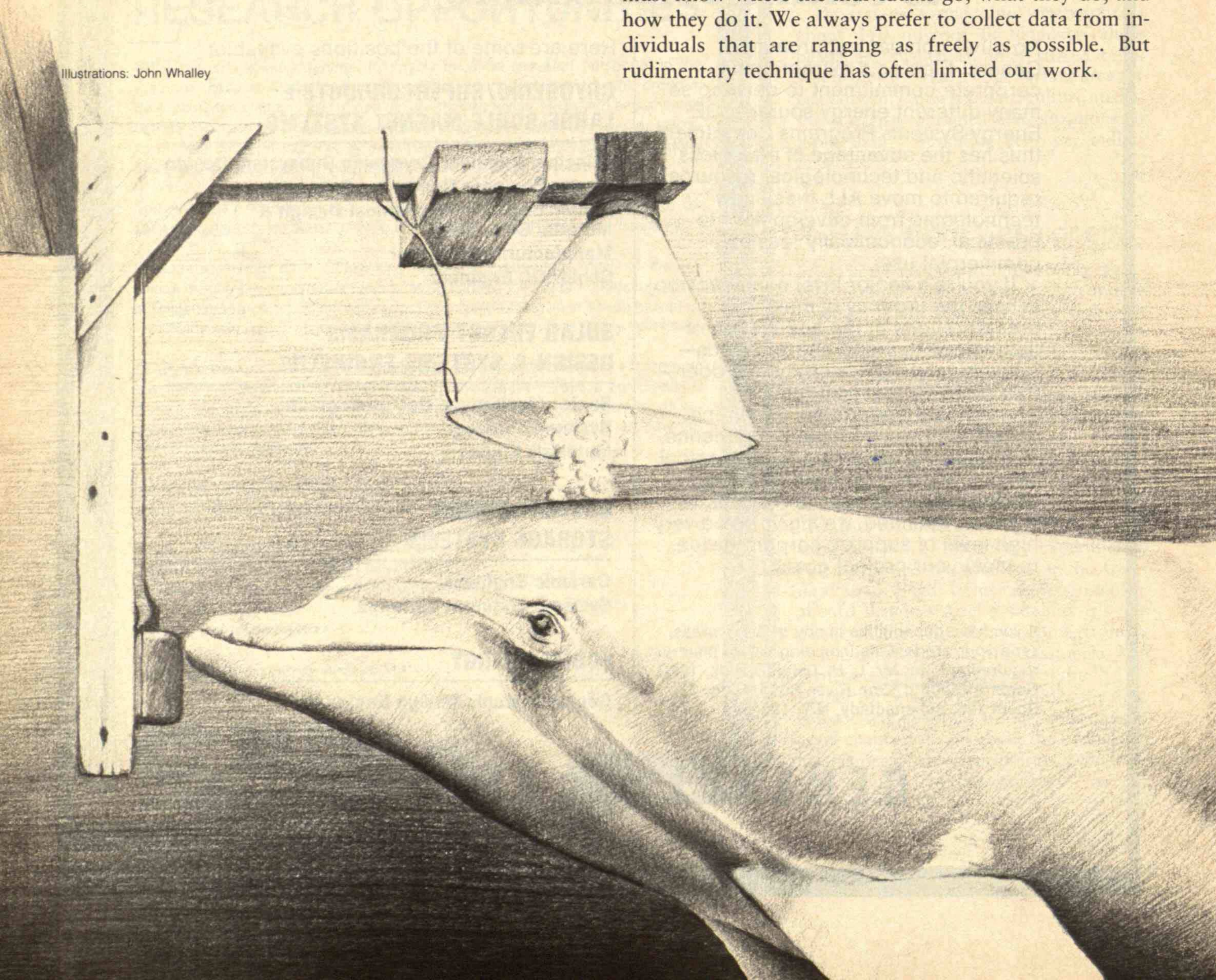
Monitoring Free-Ranging Animals

A marine physiologist brings an engineering eye to animal study.

~~Marked copy, letter, and 10 extra copies to author.~~

John W. Kanwisher

Illustrations: John Whalley



The very big usually eat the very small in the sea's interdependent food web. When a whale strains plankton through its gullet, it is as if an elephant were trying to feed on mosquitos. Life in the oceans is very sparse, so most animals' time is occupied by the unending search for food and the avoidance of becoming food for a larger creature. To elude potential captors and to find enough to eat, animals may have to travel great distances. For example, two bluefin tuna were tagged off Miami and were caught in polar seas off Norway 40 days later. We assume they had not gone to see the fjords.

So in their studies marine biologists always try to see marine life as a dynamic system made up of species as diverse as bacteria and whales. These elements of marine life vary in size by 10^{20}, and their lifespans range from 20 minutes to 20 years. All marine animals play out their diverse prey-predator strategies in oceans that can shift them over great distances. The interdependent variables of size, time, and distance tantalize us with a system of nearly overwhelming complexity. For both intellectual and practical reasons we are curious about the basic rules that govern this complicated biology, keeping in mind that understanding is a necessary prelude to intelligent management.

To understand the biology of an animal species, we must know where the individuals go, what they do, and how they do it. We always prefer to collect data from individuals that are ranging as freely as possible. But rudimentary technique has often limited our work.

Consider, for example, the task of learning an animal's capabilities by studying its physiology as it lies anaesthetized in the laboratory. To visualize how this limits our appreciation of the whole animal, imagine studying the human being from physiology alone. No amount of probing in the operating room can get us very close to the experience of a chess player or a concert violinist. Nonetheless, we must work with the means available while reminding ourselves of their shortcomings.

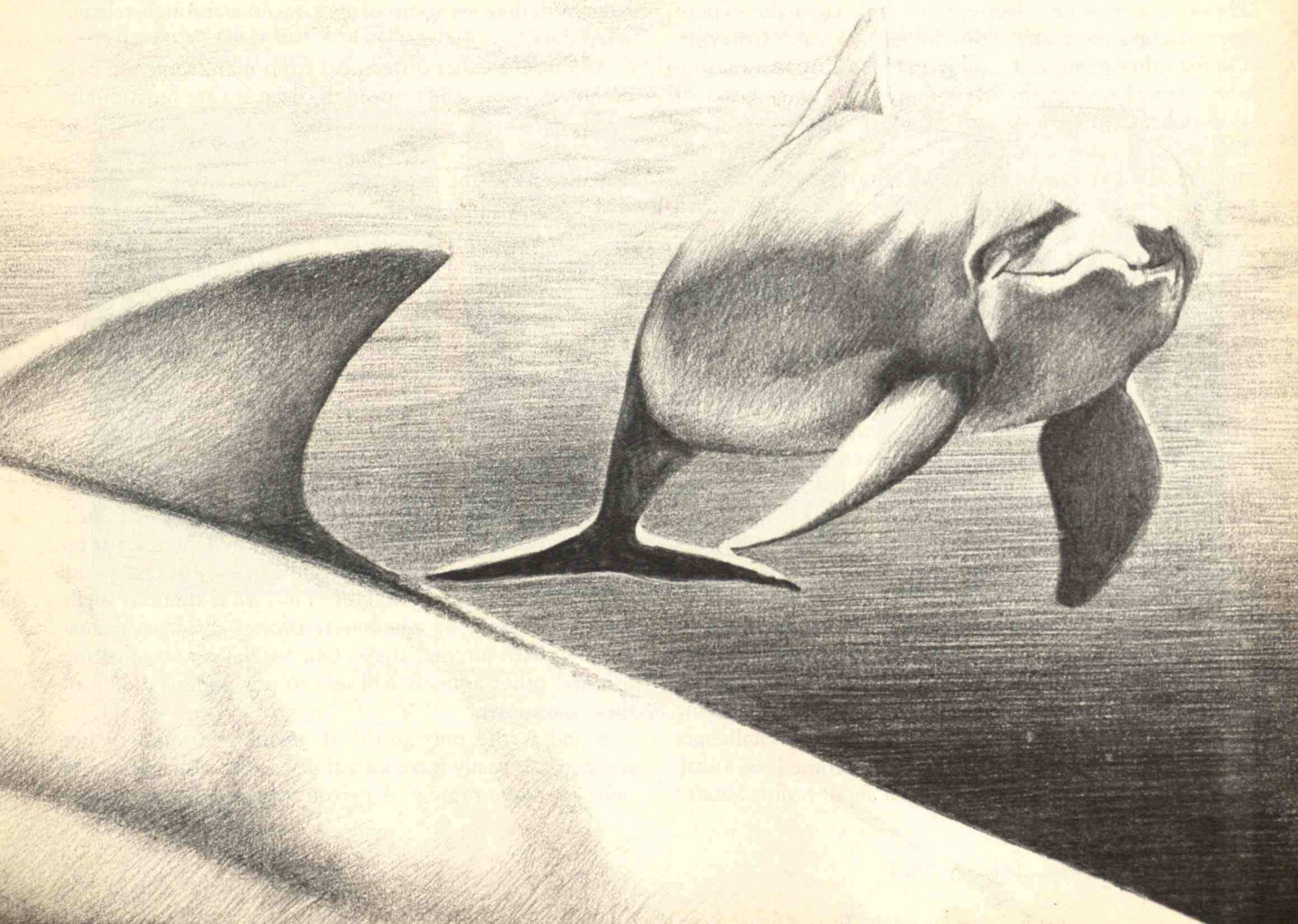
A marine physiologist like myself brings certain points of view to his animal studies, and mine have much in common with those of engineering. The animals I study are always elusive, and attempts to understand them produce more frustration than results. But increasingly sophisticated solid state electronics allow us to approach questions which a short while ago had seemed impossible. For example, a transmitter weighing only a few grams can convey the details of each heartbeat — up to 600 per minute — from a sea gull 100 km away. Acoustic telemetry now can inform us at Woods Hole of the temperature-regulating behavior of a tuna fish ranging freely in the open sea off Nova Scotia.

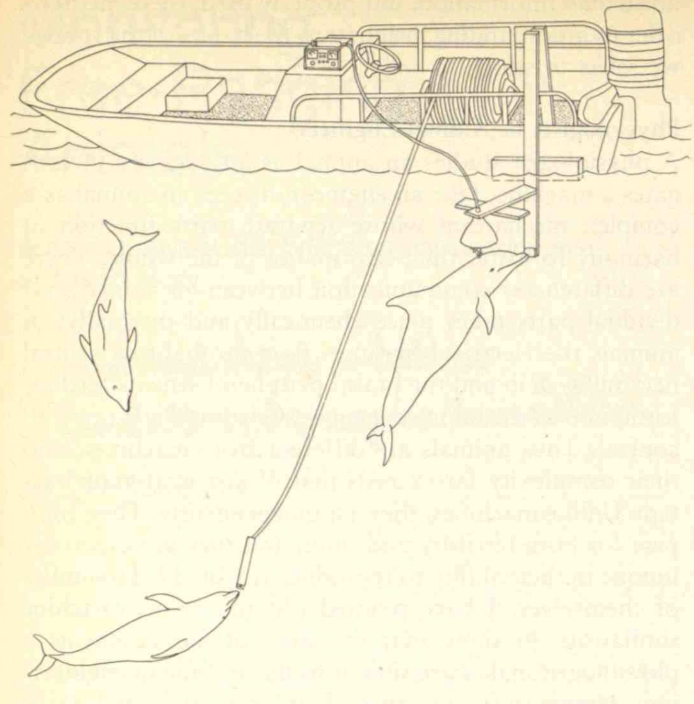
Engineering capabilities such as radar, sonar, and telemetry are applicable to the study of marine animals. We can use them to track the movement of sea animals both above and below the ocean surface. With these tools we can discover the physiological details of a free-ranging animal's inner workings. Like all new devices, these tools can seduce us into data gathering that generates more noise than information. But properly used, these methods offer us an expanding insight into the habits of the species we select to study.

Physiologists as Animal Engineers

A physiologist studies an animal as an engineer investigates a machine. Like an engineer, he sees an animal as a complex mechanism whose separate parts function in harmony to foster the performance of the whole. There are differences: communication between an animal's individual parts takes place chemically and thermally; in animals the electrical impulses flow through the central nervous system and the brain; peripheral sensors feed information to the brain so it can exercise intelligent overall control. Thus animals are different from machines, and their complexity far exceeds that of any man-made system. Unlike machines, they act independently. They compete for both territory and food, and they are especially unique in their ability to reproduce reasonable facsimilies of themselves. I have pointed out the animal-machine similarities to show that the sorts of measurements a physiologist makes are similar to those made in engineering: temperature, pressure, flow rate, potential wave forms, and such are all important. These data can tell us about the overall inner functioning of the organism.

When studying animals, the conditions under which measurements are made are critical. As an automotive engineer is concerned with the performance of a car on the highway, a marine physiologist is curious about how





Porpoises were trained to dive down 1,000 ft. to turn off a buzzer with a nudge of their noses. Returning to the surface, they exhaled into a collecting funnel (see preceding page). Determining the gas composition of the porpoises' exhalation offers clues to their unique respiration processes. (Drawing: U.S. Navy)

an experimental subject acts when it moves freely. Physiology may be adversely affected when the experimental conditions affect the animal's normal behavior. On the other hand, if the subject is ill at ease in a reasonably natural setting, the stress that shows up as faster or slower heart rates, changed breathing patterns, and the like will be meaningful. Because of this we often find that an animal's activities in artificial laboratory conditions do not correlate with the activities of the same animal when we observe it in nature.

A good example of this, and one that intrigues physiologists, is the flight physiology of a hummingbird. Hummingbirds have been made to hover in flight under a laboratory bell jar while their respiratory gas exchange was recorded. From this information we try to estimate the energy requirements of a hummingbird in flight. The numbers tell us that this quarter-ounce machine burns energy too quickly to complete long overwater flights. But no one has yet told the hummingbird. Each year he crosses the Caribbean Sea on his migration to a warmer climate. To discover how he manages, we would have to fly alongside making measurements. In the absence of such data, imagination must suffice. One person has gone so far as to suggest that the hummingbird hitchhikes southward among the feathers of much larger birds.

Our efforts to study birds by telemetry have not yet yielded a transmitter small enough to attach to a flying hummingbird. (Anyone who enjoys impossible challenges of miniaturization will be warmly welcomed as a collaborator.) We can, however, attach small radios aboard flying sea gulls. These tiny, one-milliwatt (mw) transmitters can send a crystal-controlled FM signal at 432 megaHertz (MHz) for up to two weeks. This radio allows us to monitor such details as the gull's heartbeats, breathing, whether the gull is flying or soaring, and its location. From a mountain top we can listen in on the bird's physiology to a distance of 75 km. This equipment is now included in a half-ounce package. New components, such as lithium batteries, should cut this to a quarter ounce. So blue jays, and perhaps robins, will be our next subjects, while the hummingbird remains an elusive goal.

Sound as a Telemetry Medium

The most direct way to study animals in the water is to go diving. But the oceanographer working underwater soon finds land-developed skills to be ill suited for the job. Hearing is ineffective and non-directional underwater, and visibility is limited. Diving itself can be awkward and dangerous. Humans are clearly ill equipped in both senses and physiology to explore the underwater environment in detail. Marine animals, on the other hand, have developed special abilities that allow them to function splendidly under water. Only recently have we discerned many of them.

The world of all animals is determined by their senses. They inevitably "see" things differently than humans do. Fish, for example, are acutely sensitive to vibrations below 100 Hz, while porpoises hear notes several octaves higher than humans can. If we are to understand an animal's behavior we must think of its environment in terms of its own particular sensory image. We ask the animal to help by telling us some of its concerns through telemetered data.

Among the other differences from man, some animals do not see color, and some in the deep sea are functionally blind. But recent work has shown that some sharks can detect very weak voltages in the ocean (10^{-8} volts/cm). This is equivalent to the field from a flashlight battery with one electrode in New York and the other in Miami. It would be impossible to interpret the behavior of these animals with confidence without knowing this sensory capability.

Fish are complex organisms that respond to a combination of external stimuli and internal drives. Their sensory abilities, such as the ability to "hear" low frequency sound and electric fields, are much more acute than ours. By observing their reactions, such as the temporary stopping of the heart, we know that they have "heard" a given stimulus. Telemetry allows us to monitor such perceptions in free-ranging animals with devices the size of one's little finger, over ranges of several hundred meters, for up to a month. By this method one can almost "see" the world as a fish does, and understand what stimulus spells food or danger, or whether territorial displays are associated with internal stress. Our studies on free-ranging fish and other animals will add to our understanding of these questions.

Sound is the only practical medium for underwater telemetry. It easily travels great distances, while radio and light attenuate rapidly. A person using the proper equip-

Scoping Birds By Radar

N.A.S.A.'s powerful radar installations, designed to track satellites in orbit, are surprisingly useful tools for tracking birds. The two tracking exercises have a similar need for continuous position data monitored in three dimensions and for electrical sensitivity. A rocket 4,000 miles down range, for example, will have a target strength similar to that of a large bird at 20 to 40 miles.

The 60-foot dish with half a degree beam width and 6 million watts of pulse power is far beyond anything a biologist could recruit on research merits alone. However, we have been privileged to borrow such an instrument. With it, the flight patterns of birds were followed over great distances. If we were to have an unlimited budget, the gear is pretty much what we would ask for.

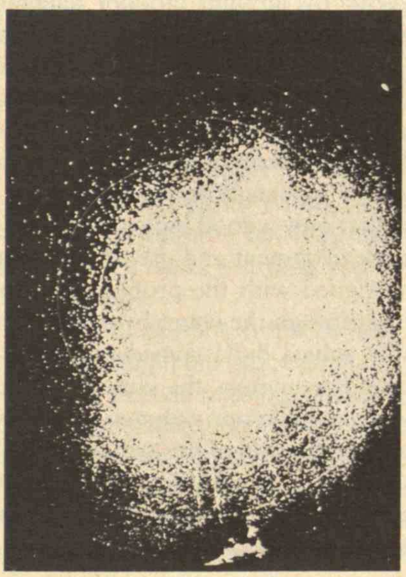
N.A.S.A. engineers frequently use this radar to track such targets as a rocket casing tumbling in flight. The rocket's varying cross section appears on screen as the changing amplitude of its reflected echoes. We can use this kind of video signature to monitor wing beats in order to identify different bird species. The time sequence of flapping and gliding varies considerably among species; thus signature measurements help identify the general type of bird we are tracking.

A quick survey of the birds in a region will be displayed on a plan position indicator scope when the antenna is scanned in azimuth. In the spring, during the evening hours of northward migration, the air may be so filled with birds (10^5 to 10^6) that the individual targets run together, compacted by the scope's finite spot size. To separate targets a portion of the tube can be expanded. Individual birds can be locked upon and tracked in much the same way as the orbiting space hardware for which the equipment was intended. Wing-beat patterns then tell us that most of the targets shown in the picture are individual birds, and an added Doppler provision on the radar indicates they are all moving in the same direction.

When targets are not too densely packed, the direction of flight can be indicated by multiple plan position indicator (p.p.i.) sweeps. After two quick sweeps there is a pause before a third. The unequal spacing of the dots on the scope shows again that most birds were moving in the same direction.

From N.A.S.A. radar at such places as Bermuda, Antigua, and Wallops Island, Va., we were able to fill in some previous unknowns. Most migrating passerine (perching) birds fly individually rather than in flocks. Many birds fly at altitudes up to 10,000 feet. Some, particularly over the West Indies, may fly as high as 18,000 feet. How they handle respiration in half the oxygen of sea level is another puzzle for physiologists to ponder. One is impressed also with the aerodynamics of the bird bodies which can fly at this much lower atmospheric density.

An interesting mystery has been whether or not small migrating land birds, flying south in the fall, take the shorter direct route to the tropics down the center of the Atlantic. There is no way of refueling or resting on this route because the birds cannot land on the water. Oceanographic vessels have always had many migrating land species light on their decks in the fall. The voyage logs of Columbus mention such land birds when he was south of Bermuda in September. But the historian Samuel E. Morrison disallowed this, since bird watchers expressed the opinion that such flights were impossible. Fortunately, N.A.S.A. has a Bermuda tracking radar. The multiple sweep scope picture below was made with it. There is little doubt that it shows a directed mass migration. Columbus was apparently not just cheering his crew on with false evidence of an imminent landfall. —*J.K.*



Migrating birds literally cover the sky on spring evenings. This radar screen shows between 100,000 and 1,000,000 birds in one sweep.

Rhythmic radar sweeps can show the direction of migrating birds' flight. After two sweeps, there is a pause before the third. In the picture, the birds are travelling in a northeasterly direction.

Tracking radar located in Bermuda uses multiple sweeps to prove that the birds it is tracking are participating in a directed mass migration.

ment can hear the noise made by an exploding pound of dynamite over the entire North Atlantic. Several properties of sound in water are important. For example, greater range is possible in fresh water than salt (although one rarely has a choice in this matter). Low frequencies transmit farther than high ones, although for distances up to several hundred meters, any frequency below 100 kiloHertz (kHz) will suit. If a range of several kilometers is needed, the sound frequency should be under 20 kHz. Low frequencies, however, involve longer wave lengths and require large transducers to pick them up. In the small devices necessary for fish studies, these are difficult to use. Thus we most often employ frequencies between 40 and 80 kHz. Only in large fish, such as tuna, can we use a transmitter big enough to work efficiently at 20 kHz, and these have an open sea range of eight kilometers.

Sensitive receivers allow us to monitor signals over long distances. The hydrophone, an underwater microphone which may be directional, can pick up a sound and translate it into an electrical signal that the receiver can amplify. A good signal-to-noise ratio in the receiver is obtained when this input signal is one microvolt or more. Since our hydrophones normally have a typical resistance of 1,000 Ohms the amount of acoustic power that must be intercepted to produce this signal is only 10^{-15} W. Such a low minimum-detectable energy is the key to the successful functioning of the acoustic telemetry links. As a working example, one of our smaller fish transmitters puts out 100 microwatts. If a 10-percent-efficient receiving hydrophone sees only 10^{-10} of this, such a transmitter will be heard. Under quiet conditions, we can obtain impressive ranges from these small amounts of power. The size, and therefore the power, of an instrument can be increased greatly if it is carried by a human diver. In planning experiments, one must remember that transmission across entire oceans is impossible with a minuscule device.

Interfering background noise naturally tends to obscure a signal. This noise varies greatly at different places. In general, the shallow-water tropics are noisiest. The natural acoustic energy in Hawaii may be 100 times greater than that in Puget Sound. Most of this noise is generated by bottom-dwelling animals; the snapping of shrimp is heard often. Man-made noise, like that from boat motors, can also be troublesome.

Sound also has some properties that complicate its use in telemetry. The relative motion between a sound source and a receiver produces a Doppler shift in the apparent frequency of a sound. The normal velocity of sound in water is about 1,500 meters per second. From this one can calculate that a relative velocity of one knot will shift the frequency by 0.03 per cent. This becomes significant when frequency is used as a code in gathering data. We usually use frequency modulation with excursions 100 times greater than this Doppler shift.

More important are the interference effects due to multiple sound paths between transmitter and receiver. These are frequently troublesome in small enclosures where sound reflects from the walls. Nulls in the sound field may occur, which show up as a momentary loss of signal. The resulting rapid changes in phase and amplitude can be only partly overcome by good receiver design. Fortunately the ear usually can interpret heavily distorted signals which have a characteristic signature, such as that of an electrocardiogram. But it may be difficult to transcribe a faithful replica on a penwriter.

Acoustic telemetry is also severely limited in band width. One can usually not put more than 10 or 15 kHz into a single system, out of the 20 to 100 kHz band that is our practical limit. By way of example, the human voice requires 3 to 5 kHz for minimum intelligibility. Thus divers can talk to each other and to the surface ship by acoustic links. But a television picture would require a thousand times the band width, and cannot be transmitted even poorly in real time.

The technical challenge of pushing the band width in an acoustic link to the limit was central in one of my experiments. The study involved monitoring the activity of a particular type of cell (Perøkinje) in the brain of a free-ranging shark. The amplitude and frequency of the nerve impulses were needed. We could just manage to determine both with a state-of-the-art phase-lock FM system — our best receiver system.

I must add that the engineering triumph did not produce a deep understanding of shark brain function. The means by which we placed the micro-electrode made it necessary to choose from the million such cells at random. Some had exciting properties, and fired only when an object passed through a certain part of the shark's visual field. But we never discovered two that behaved alike, and only occasionally could we correlate the cells' activity with an observable stimulus. I reluctantly concluded that our efforts were like trying to understand the sociology of New York by tapping random telephone lines. If you happened upon the mayor, or the office of the Mets, some insight might be had. But most of the time you'd hear the random noise of Bronx householders exchanging recipes. And since we don't speak the cells' language, we were little better off than an English-speaking eavesdropper in Moscow or Bangkok.

I learned from this that only a good biological question should determine the development and use of instrumentation. I had been intrigued with the problem of transmitting nerve impulses through the water by sound. Only after the problem was solved did I consider whether it was a good experiment. Fortunately, the same equipment may be working soon on single optic nerves of crabs: a reasonable scientific interpretation of this will be possible. My scientific past is littered with technical triumphs that were biological failures. Since I am responsible for both, I have no one to blame.

To the Heart of the Flounder

We have used acoustic telemetry to study the energetics of a swimming fish. Swimming fast, the fish shows an expected increase in heart rate. The greater rate indicates the increased oxygen transport of the cardiovascular system. Chasing a fish to maximum fatigue can result in an increased heart rate that lasts for as long as 10 to 20

MIT '78

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Articles

The Class of 1978 makes June 5 a memorable Commencement Day **A1**

Marjorie Lyon meets the Class of 1978: she's "surprised," "intrigued," and "ready to cheer" **A8**

"Exhilaration" and "discipline" describe the M.I.T. Symphony Orchestra in Avery Fisher Hall **A14**

Departments

Students A17
William Lasser, '78, on the revitalization of student government **A19**

Courses A21

Under the Domes A29

People A30

They Took 1,200 Degrees and Left "a Renewed Spirit" for Those Who Stay Behind

Graduation. One of those moments that hang in time to be experienced and remembered with a mixture of solemnity, gaiety, pride, nostalgia, excitement, and relief. Conflicting and powerful emotions — there hiding under even the most casual exterior.

"Ignore any cynical comments your offspring might make ('I'm doing it for you')," Arthur Mattuck, Professor of Mathematics, told parents on graduation eve Sunday night. "When the band strikes up, the students will be pleased you're there — but they won't tell you. . . . I always complain," he added, "but it's nice — it gets you — and I'm as tough as they come that way." He's right.

The atmosphere in the Armory, the huge space jammed with graduates ready to begin the procession, is fraught with last-minute panic — safety pins needed, tassles missing, orders coming from the director, megaphone in hand: "You absolutely cannot get out of line now without permission from the Registrar." In the Rockwell Cage, the faculty begins the procession and it seems like a family reunion — in costume. Red hats, colorful capes, familiar faces transformed in the regalia, smiling at each other with a warmth and friendliness that echoes throughout the gathering of graduates, parents, friends, faculty, and journalists.

also p. A4

The graduating class seemed different this year. James L. Bidigare, Jr., '78, Class President, described this change in his speech as the senior class representative (*see page A4*): "A commitment to make M.I.T. a more positive experience for all students is slowly replacing the apathy that followed the activism of the 1960s. . . . When we all leave today, I think that we will carry something with us even more important than a degree; we will have the knowledge that M.I.T. has been left with something from *us* — a renewed

Beginning M.I.T.'s 112th Commencement on June 9 with the colorful academic procession into Rockwell Cage was Dr. Carola B. Eisenberg, Dean for Student Affairs, and Chancellor Paul E. Gray, '54. They joined 700 graduating seniors, 500 graduate students, and more than 3,000 parents, wives, children and other relatives. Afterwards, the graduates and their families were honored by the President, Chancellor and faculty at a reception on Kresge Plaza. (Photos on pages A1-A4: John M. Grunsfeld, '78)

see also p. A19
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spirit for its students."

But back up a minute, to the night before. Arthur Mattuck spoke with humor, thoughtfulness, and wisdom to parents and students in Kresge Auditorium. His words evoked those emotions to be felt again the next morning.

Sometimes humor:

Imagine a scene from Charlie Chaplin's "Modern Times": Mr. Chaplin is stuck inside an experimental eating machine. The food comes rolling by him . . . at first slowly — soup, gently spooned, corn, slowly turning as he happily chomps, a fork carefully lifting meat to his mouth. But then the machine speeds up until everything is being thrown at him at once. Soup splashing, corn wildly spinning, fork jabbing at his face. "In my gloomier moments, that's the M.I.T. education." (Applause) "Problem sets come hard and fast."

Sometimes solemn:

"Some of you are very successful at budgeting time. One such student I knew said he was perfectly organized . . . he knew where he would be every minute for the next semester. Most of us are not like that. We muddle through, meeting one crisis after another, finding out what's quizzable material and what isn't. We ask others ('Sure it's important, but he'll never ask it'); we psyche out professors.

"The problem is that each professor wants the one quarter of your mind he or she feels entitled to each semester. Think of four kids each pulling on a teddy bear, dismembering the poor little creature.

"The problem is that each professor wants the one quarter of your mind he or she feels entitled to each semester. Think of four kids each pulling on a teddy bear, dismembering the poor little creature."

"It may seem terrible, but it's great training for the future. In spite of crises, somehow you all got through. Some of you sailed through, others can only be described as Brownian motion — changing again and again, dropping out, putting together courses, piecing together a major. Some got the education they wanted, others were disappointed."

Sometimes reminiscing:

"Parents — you probably haven't been here since you brought the

"I hope over the four years here you learned to deal with more complex problems — with ambiguity, where the data is unclear, the tools are unclear. You can't know the tools from a chapter of a book, but you find what you can use from the entire world. You don't know if the problem even has an answer. *Those* are real world problems."

bags up, four years ago, shook President Wiesner's hand, and then were sent packing. There have been lots of changes since then . . .

"First of all, the campus itself. Three months ago, you should have seen it — huge snow monsters, prehistoric dinosaurs carved by students, an igloo in the middle of the river for cross-country skiers to stop for refreshments.

"The 'Big Screw' contest was won by the administrator who ordered construction on the new chemical engineering building to begin at 6 a.m. the first day of finals week.

"There always seems to be a spring issue. Last year, Harvard and M.I.T. were shaken up by proposed ban on research on DNA — fears of something creeping out of their test tubes to start a new race. This year, there was the stock M.I.T. holds in companies that do business in South Africa. These issues have been raised by students, not faculty, and I feel proud of them because they sensitized the faculty and administration."

And sometimes wise:

"I do hope you got what I see as the central intellectual experience at M.I.T. In a freshmen calculus course there is a definite answer to every problem. I hope over the four years here you learned to deal with more complex problems — with ambiguity, where the data is unclear, the tools are unclear. You can't know the tools from a chapter of a book, but you find what you can use from the entire world. You don't know if the problem even has an answer. *Those* are real world problems. We can't begin an education with that — it's too unsettling and difficult. But I hope it could end like that.

"It's customary to conclude by handing out some wisdom . . . I learned something a long time ago that is still relevant today. Marvin L. Minsky, Donner Professor of Science, and I were good friends. One day he asked me over to dinner. When I walked in he had the gleam of discovery in his eye. "Arthur!" he exclaimed. "Do you realize that in the morning, if you wash your neck your shirts will stay cleaner much longer?" — *M.L.*

1978: Down-to-Earth People Who Helped Turn M.I.T. Around

Following is the text of remarks by James L. Bidigare, Jr., '78, speaking for his Class as President at the Graduation Exercises on June 5:

With our families and friends here this weekend, we've all been trying to convey the M.I.T. experience of the past four years. This is one of the most difficult tasks we students have faced here. You really have to have gone through M.I.T. to appreciate what a degree from here means.

The experience has been "intense," to say the least! While most of us have had our confidence shaken and tested, we are coming out of here knowing we can handle pretty much anything, especially proven by our getting through four years of M.I.T.; and that's a great assurance for the future.

Some of the friendships we've developed over these past four years of our lives will last forever. Only in the last few months have we realized what we'll be leaving. We *won't* miss the problem sets and other pressures of M.I.T. all too much, I'm sure, but we *will* miss the best part of M.I.T. — the people, each other. Whether it be living group, department, activity, or sport, there is some group of people that you could call your own. Something like that will be hard to recreate once we have left. We'll all take on the responsibility of maintaining the friendships we've made, no matter where we find ourselves — at work or in school in any part of the world. We will make even more ties with our classmates after we leave today.

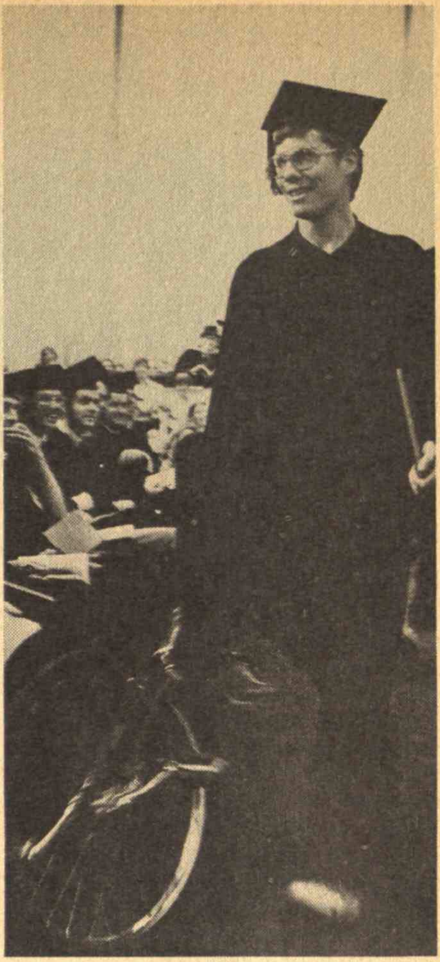
The exactness of science and the analytical aspects of engineering have made us fairly down-to-earth people. There is a genuine element of concern and generosity among members of this class which has never ceased to amaze me. All it takes is someone to ask, and you volunteer to help, offer to listen, try to help people grow as they should at this time in life. The commitments many of you made to activities, sports, or living groups, even in the midst of the academic pressure, shows a real desire to initiate change and improvements, to grow.

A commitment to make M.I.T. a more positive experience for all students is slowly replacing the apathy that followed the activism of the 1960s. You in the Class of 1978 have been part of this turnaround, helping with your enthusiasm and initiative.

When we all leave today, I think that we will carry something with us even more important than a degree; we will have the knowledge that M.I.T. has been left with something from us — a renewed spirit for its students.

P. R. Platero

L. M. Jeanne



J. Christopher Hind, '78, — a unicyclist — rode across the stage to receive his degree. (Photo: John M. Grunsfeld, '78)

Ending the Foreign Domination of American Indian Linguistics

LaVerne Masayesva Jeanne is a Hopi from Hotevilla, Ariz.; Paul R. Platero a Navajo from Canoncito, N. Mex. Both received Ph.D.s in linguistics at M.I.T. on June 5 — probably the first native Americans ever to hold doctorates in that field.

Both came to M.I.T. five years ago to work with Kenneth L. Hale, Professor of Linguistics, who is a student of native American languages — of which there are some 300. One of Professor Hale's goals is to help American Indians study their languages themselves.

Most major contributions to linguistics over the years have been made by people working in their own languages, Professor Hale says — English scholars working on English, Japanese on Japanese. But language study of American Indians "has been dominated by 'outsiders' for more than 200 years," says Professor Hale, and "the linguistic fate of American Indian communities is being decided by outsiders."

That's wrong, he thinks, for three reasons:

□ We need effective scholars of the American Indian languages simply to help maintain the languages — and through them the identity of these peoples.

□ We need better ways of using their languages in teaching American Indian children.

□ We need better understanding of American Indian languages for what they can tell about the origins and development of the people who use them.

Having finished their M.I.T. degrees, Drs. Jeanne and Platero will do precisely what Professor Hale has in mind. Dr. Jeanne is in linguistics at the University of Arizona, where she'll help and encourage others of her people to enter the field; and Dr. Platero is working on educational materials for bilingual teaching at the North American Materials Development Center in Albuquerque, N. Mex.

Commissions to 23 New Officers: Seven Sworn In by Their Fathers

Commencement began three days early for 23 members of the Class of 1978 receiving commissions in the military services after four years of R.O.T.C. training at M.I.T. — nine in the Navy, eight in the Army, five in the Air Force, and one in the Marine Corps.

M.I.T. is unusual in offering R.O.T.C. in the three major branches of the military, and on June 2 Curtis H. Fennell, '78, made it four: he is the first Navy midshipman commissioned into the Marine Corps at the Institute.

The Commissioning Exercises were unusual, too, when seven commissioned officers in the military services were called on to administer oaths of office to their children who were receiving commissions in the Class of 1978.

A Ph.D. With More Than Honors

When Dean Harold J. Hanham called the name of James Paul Barber for a Ph.D. degree in political science at the Graduate Exercises on June 5, no one came across the stage.

Dr. Barber's degree was awarded posthumously; he died last January 10.

During most of Dr. Barber's life he was preoccupied by his struggle against crippling physical handicaps. Surgery for a brain tumor at age seven left him without control of neck, shoulders, and arms; and ever since then Dr. Barber required help to do what most of us take for granted.

But he had a lively interest in government and politics and an indomitable will to conquer his handicaps. So it was that Dr. Barber graduated with honors from Harvard in 1972 and came to M.I.T. that fall to specialize in the delivery of health and rehabilitation services to the handicapped. His thesis was a comparison of vocational rehabilitation programs in state-controlled and "free" societies, and his research included more than three months' work in the U.S.S.R. in 1975 studying Soviet health care systems.

Last January Dr. Barber fell victim to pneumonia at the age of 27. ". . . a fabulous person," says Professor Michael Lipsky; ". . . a symbol of courage," wrote Donald L. M. Blackmer, Associate Dean of the School of Humanities and Social Science.

A New Priority for Caring in a Society Rebuilding Itself

Following are excerpts from the address of Jerome B. Wiesner, President, to the Class of 1978 at Graduation Exercises on June 5:

Three themes emerged most frequently in suggestions made by some members of the Class on subjects they wanted me to talk about this morning. First, a strong wish to celebrate this occasion in personal terms, not only as one of accomplishment but as a way to emphasize the warm friendships and strong bonds that have grown up among you. If you follow the patterns of past alumni, these bonds will give you joy and support all of your lives.

The second issue also had to do with people, but it had to do with the friends *not* made, with a belief that as a community we are insensitive to the need of many of our members — particularly students and young faculty — for friendship, understanding, encouragement and support. I heard a concern, too, about stresses between groups on the campus, about a growing polarization of foreign students from different countries and a deep distress that positive dialogue between black and white students has been almost non-existent and these two groups frequently at serious odds.

These two themes, I believe, are actually two facets of the same deep and vital human emotion: *caring* — caring for social groups, caring for institutions.

The third issue students have talked to me about, not surprisingly, is the role of their professions in the welfare of our nation and the world — I call this caring, too, a reflection of the universal hopes and concerns for the role of science and technology; caring about spending your lives in constructive pursuits.

I am confident that you have acquired enough knowledge to begin your professional careers. The graduation ceremony is traditionally called commencement, because the society, and in particular the university, expresses its confidence that you are now ready to take your place as full-fledged participants in the affairs of the world. Professional expertise is essential, of course, but it is just a start — most of you have learned much more than that. Here is what I mean.

How to think clearly. How to work hard (I know from some of your complaints that you have at least been challenged to work hard). To have the courage of your convictions. (I hasten to say that I have considerable evidence that at least some of you have learned not only to have the courage of your convictions but how to express them forcefully.) I hope that you have found that creative activity can be very satisfying. I know also — as I have already said — that many of you have discovered that creating warm personal relationships — in work, in play, and especially in helping others — can be a source of continuing personal satisfaction.

Perhaps most important of all, I hope that you have acquired a substantial degree of humility in the use of your knowledge and your power. If the M.I.T. experience of learning by involvement, by doing, has been successful, you must realize how often what you thought you understood turned out to be half right or occasionally totally wrong, and how easy it is to make mistakes as you strive to solve a problem, and how fragmentary is our understanding of many vital problems which still remain. Incidentally, a bit of modesty might even disarm future non-M.I.T. colleagues — frequently people who don't know us tend to be a little in awe of M.I.T. They sometimes seem to expect us to talk in code or sounds like R2D2 in *Star Wars*. You will find that many people hold a schizophrenic view of your work without much understanding of it. They will look to you, perhaps too trustingly, for the technical miracles needed to keep society healthy and move it ahead; and, at the same time, they will hold you responsible for all the developments they are frightened of. So, in addition to continuing to learn, you have a major communication job cut out for you.

These have always been the expectations for the M.I.T. experience. But these questions are much more in the air today than they were even two or three decades ago, and they will doubtless be a major and continuing concern for you and your non-technical peers. We live in a time of extraordinary turmoil, in which there is much fear and suspicion and real danger and in which confrontation has become too much the normal style of dialogue. Issues move swiftly to the courts, by-passing traditional discussion and compromise, common understanding, and trust. Differences are accentuated and common goals and common humanity are difficult to keep in sight, making many people feel estranged from both their colleagues and their institutions. To counteract this dangerous trend, each of us needs to make a special effort at understanding and caring.

New Rules of the Game

A recent poll of the mood of American citizens by Daniel Yankelovich and Associates gave me some comfort because it put our M.I.T. situation in a broader context. The pollsters found that the majority of Americans, young and old, believe themselves to be living in a time when the rules by which they live and work are changing drastically, fundamentally, based upon a whole set of new expectations, new relationships, and new moralities. Many are concerned that these changes are occurring too rapidly and painfully, but nonetheless they want them. These new rules apply to both individuals and institutions — government, business, and public service. Central to the new rules of the game, the poll showed, is an emphasis on individualism and a greater expectation of fairness, characterized by a desire to have more control of one's own destiny in a world which seems at the same time to demand more conformity. This showed me that the issues that trouble us here at M.I.T. are a reflection of those that concern the society at large, and therefore I took some comfort in the poll's revelations. It's not only that "misery loves company" but that perhaps the high level of unease is not our fault alone. Furthermore, I believe that we can take some assurance from knowing that as an institution and as individuals we have been contributing knowledge and guidance that will slowly but surely help formulate appropriate new rules of the game.

The poll also showed an almost universally deep suspicion of all institutions — universities, corporations, and governments — with an especial fear of the growing pervasiveness of government. I happen to be-

lieve that this fear of government is a most healthy sign, for governments have historically posed the greatest threat to individual freedom. We are experiencing a reaction against size and impersonality and regulation, and people of all political viewpoints are coming together on this issue.

The desire for more freedom of choice is in conflict with another major demand of the times for more security. This leads to an increasingly dependent relationship between individuals and the institutions with which they are associated, as well as government — somewhat like a life-long parental relationship. Perhaps that's why there is a growing tension between them. This desire for security, a no-risk society, results in major contradictions between hopes and expectations on the one hand and the kind of innovative, risk-taking attitude that has made it possible for our country to come this far. If our country is not able to fulfill our expectations and needs — in the energy area, for example — it won't be for the lack of natural resources or technical possibilities, but rather because we have become too dependent upon seeking solutions through confrontation and regulation instead of problem-solving initiatives. The nation's ability to satisfy our expectations is being inhibited, ironically, by continuing antagonism toward the institutions that must lead the way, including universities and business.

Trial and Error — and Positive Feedback

The antagonisms and the accompanying stresses we face are to be expected because the push for new rules of the game stems from the fears and hopes of many individuals and groups having interrelated but often conflicting objectives that must somehow be reconciled. I like to think that this is the noise of a society at work, experimenting, improving itself. Inevitably, progress must involve much trial and error and compromise. Experience is already showing that some aspects of the new rules of the game are in conflict with the conditions for an effective evolutionary process and will have to be modified. We see signs of this in the reexamination of educational programs, in the effort to reconcile environmental regulation and energy needs, and in the attempts to understand how tax laws and regulations have slowed down the innovative process. This is all part of learning. I am reasonably confident that we will overcome the problems that look so formidable today, but we will certainly face new and equally challenging difficulties even as we overcome the present ones. A dynamic society will inevitably produce uncertainty and stress.

We can all speed up this process by the work we do and by trying to make our part of the world more humane by replacing suspicion with understanding and self-centeredness with friendship. Institutions are people, and caring people make supportive institutions. It is important, in seeking to deal with our current uncertainties, to care for the democracy itself which, by its very fundamental ideals, provides the basis for our present efforts to make a better world.

What's more, caring is contagious — positive feedback will really work here. While I was thinking about this, I made a simple calculation to illustrate my point. It is perhaps a fantasy; the result was obviously far-fetched, but it made me think a little harder about the idea of helping and I think it worth telling you about.

I tried to see what a little additional caring, a modicum of extra consideration, could do in a place like M.I.T. There are roughly 16,000 people at the Institute. If each of us added one per cent of consideration to our interactions with everyone else, the effect measured in total happiness would be astounding. Can you calculate $(1.01)^{16,000}$? My pocket calculator blinked violently when I tried it but finally produced 1.386×10^{69}. Fortunately, all 16,000 of us don't interact with each other every day or we couldn't stand the goodwill! What does a one per cent increase in caring amount to? It could mean an extra half-hour a week devoted to a needy community or group activity or just spending the time in small bits of a few seconds or minutes cheering someone's day. I know, of course, that many people at M.I.T. already spend much more than a half-hour per week in this way. I am just trying to show what could happen if we *all* gave *caring* a priority.

Perhaps I may seem too optimistic to you this morning, considering all of the critical issues we are confronting at this time, but I happen to believe that we can make the world a better place.

You should know, too, that much of my optimism comes from knowing *you*. We are in the midst of a major re-do of our society, seeking to improve the many things that are less than optimum. This is a process that will be heavily dependent upon the role of science and technology, extraordinarily good management and sensitivity to the human condition. This is wonderful challenge and exciting opportunity.

Meet Ten M.I.T. Students: Travelers, Thinkers, and Doers Who Are Mature Beyond their Years

Look from a safe distance and M.I.T. students blend into that famous stereotype. You know the words: slide rule (or calculator), unkempt, shy, narrow, Tech tools (but bright, of course). The all-inclusive label: gnurd. I hear it again and again.

But come closer. Just a little. Make yourself comfortable. Sit down and talk to a few young people who have just completed four years as M.I.T. undergraduates (you know, those gnurds). Ask them about themselves, what they've done here, who they are, where they're going.

I did. And you might be very surprised, intrigued, and — well, yes — ready to stand up and cheer. — *M.L.*

"We would get up at 4:00 or 5:00 and go to sleep at 10:00 — and just sit still (perhaps three hours in the same position.) On the sixth day I remember in the back of my mind thinking I have to take a physics course. How am I going to explain this disparity? Running around half-naked with holy men in India seemed in stark contrast with the kinds of knowing on which M.I.T. places a premium."

Walter Witryol, '78

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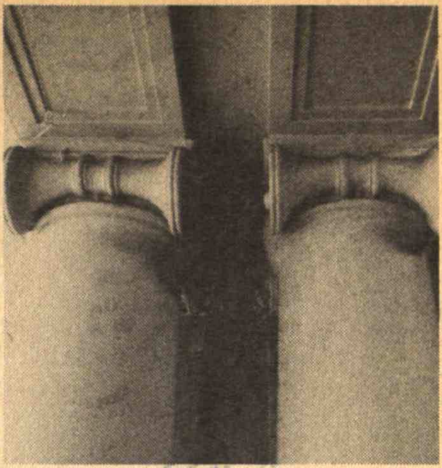
The late afternoon sun held a surprising warmth; sitting in Killian Court was especially pleasant. My company: Walter Witryol, '78 — unassuming, soft spoken, thoughtful, slight. Not shy, though — and certainly not one of those M.I.T. statistics (but no one was, it turned out). My interest peaked the more he talked. . .

His description of his "downright hostile" approach to school ("I didn't see any reason to be here except to please my father, a professor who thought college was the be-all-end-all") contrasted with an obvious love of learning. His was an unusual program for M.I.T., prompted by his primary interest, the study of religion.

He spent his junior year in an International Honors Program studying religion in eight different countries around the world with a group of 30 students and three professors. The last stop was Japan, where he stayed during last summer.

I listened, as the sun became cooler and the shadows in the courtyard lengthened, to his philosophy. The ideas seemed to stem from his study in the Far East, much reading and thought. They hardly seemed appropriate (or even possible, I might add) from a 21-year-old student. (I began to think he might be a disguised 110-year-old sage.)

"I disdain comfort because in my mind the most basic law of existence is that everything changes. Comfort always transforms into the opposite — so I seek the opposite. And if I actively seek discomfort, if comfort comes my way, I'm not disappointed." He talked about discomfort as the idea of training, or "tuning yourself in with the ideas of the universe." Training is not punishing yourself. "I don't do Aikido to get stronger, but because every hour I do it I enjoy it. If you're enjoying yourself you're on the road to harmonizing yourself with change. Discomfort is leaving yourself a little empty — not torturing yourself — but not satiating yourself. The Western ethic tries to arrogantly flaunt most fundamental laws of existence (change). An example is the way Westerners control temperature change in



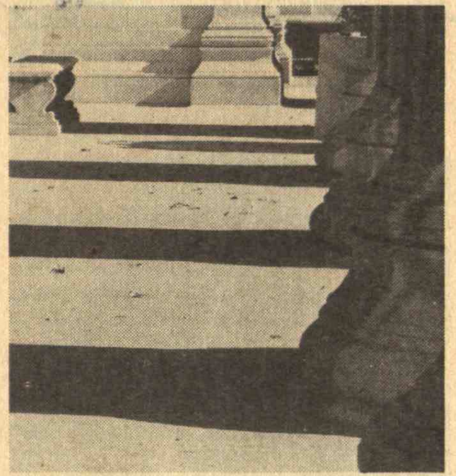
buildings. In other countries they more readily accept the heat of summer and the cold of winter. The idea of keeping the Astrodome at 72 degrees is symptomatic of the outlook of our whole civilization, and we're clearly facing the limits of that way of thinking (called the energy crisis).

"Resistance to change may be in a sense what ego is — actively trying to resist the way things work (you can call it God, or supreme truth, or the laws of physics). When you try to thwart that (I want to live forever, I never want to be hungry, I never want to be sad), you are unrealistic. Happiness can't exist without sadness. There can't be an angel without a devil, success doesn't come without difficulty — and that's what I mean about training. If I want one thing I must be prepared to accept its opposite for a while. Go for difficulty, because difficulty is really the means for providing you with your end. (People tend to learn the most when the difficulty is neither small nor overwhelming. But rarely in life do you get such choices. When studying, you can choose to take calculus one before calculus two.)"

I was fascinated by anecdotes of his travels: his participation in the Khumba Mela, for instance, a Hindu religious festival held every 12 years. Ten to 20 million people gather and bathe where three rivers meet. I was trying to picture him smashed in the water with six or eight million people, shoulder to shoulder, naked in freezing water. (My life began to seem relatively dull.)

"Once I was caught on a packed train for 38 hours, to go 70 miles. It was impossible to get out. And the crowd was desperate to get on; they ripped off the doors. . . . That kind of experience I'll always remember. I can't guess about the implication of it on my philosophy of life. The danger of this age is you get so much second-hand experience from TV and books, you don't get as many real experiences."

He described a ten-day intensive meditation course in India: "We would get up at 4:00 or 5:00 and go to sleep at 10:00 — and just sit still (perhaps three hours in the same position). On the sixth day I remember in the back of my mind thinking I have to take a physics course. How am I going to explain this disparity? Running around half-naked



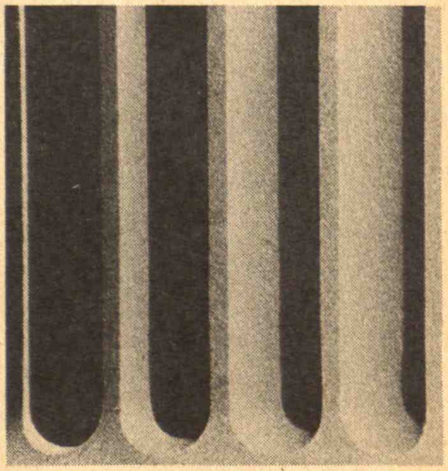
with holy men in India seemed in stark contrast with the kinds of knowing on which M.I.T. places a premium." He smiles. "Most of what I've learned (about religion, Chinese medicine, history of science, Japan) has little to do with what I've studied formally."

I was intrigued by his thoughts on M.I.T.: "If there is any skill I've learned here it's how to be an independent learner. I don't know if it is explicitly taught here, but implicitly it seems to get around.

"People here have an acumen which I can't verbalize, a common sense that I really value. Part of my appreciation comes from experience at Harvard and with students I traveled with who were from other universities. A lot of them tended to cut off a way of looking at the world that could be described as the 'scientific' view. I get a lot of influence from my peers, and at M.I.T. their range of competency is extremely diverse. Here people can solve differential equations and write poetry in the same afternoon.

"People tend to be scared of math. But there are certain individuals here who really look at something very carefully and say 'What is this thing doing, what's going on?' It is a sensitivity I haven't found elsewhere. If in any sense I'm proud to be at M.I.T. — and I'm not proud of titles and positions — it's from being associated with these people. They work very hard — and many are very humble. Even though I was a big fish in high school, I'm in a big pond now, and this makes me hungry. It's called in Islam 'spiritual poverty' — you don't get soft and

"The Western ethic tries to arrogantly flaunt most fundamental laws of existence (change). An example is the way Westerners control temperature change in buildings. In other countries they more readily accept the heat of summer and the cold of winter. The idea of keeping the Astrodome at 72 degrees is symptomatic of the outlook of our whole civilization, and we're clearly facint the limits of that way of thinking (called the energy crisis)."



"If there is any skill I've learned here it's how to be an independent learner."

lose your edge here."

Interests and current pursuits: Aikido, history of science, studying Japanese, movies, reading, papermaking, calligraphy, Hebrew, bookbinding, Noh (Japanese drama), the study of finger pressure (shiatsu) message.

And the future? "I would like to go back to Japan." As for work, "I would like to work at a humble job. Not that I mind using my degree for work, but I'm more interested in doing work that doesn't require a college degree, like physical labor, because I've never had that experience.

"I look on the future as an opportunity to realize an infinite dream. I know what I want to do — the certainty is there but certainty is in a relative world. I don't want to do anything small. I want to help transform the world. I believe that we're collectively reaching an important stage in our development. I want to help create the most harmonious way of going through the critical period which I see coming."

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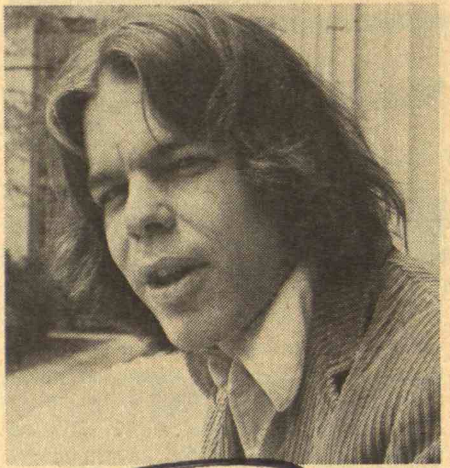

Jeffrey M. Vandegrift, '78

"I took time off because I realized that then, I was in school only because it was assumed I'd be there."

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Jeff spent one year at the University of California at Santa Cruz, then took one and one-half years off before coming to M.I.T. "I took time off because I realized that then, I was in school only because it was assumed I'd be there." A major factor in attracting him to M.I.T. was the work-study program.

"There are more serious students here than at Santa Cruz. I can rely on the fact that other people are doing interesting things and automatically work harder," he says. "I was a dedicated student here — sat around and tooled all the time. But after one and one-half years I got bored, and at the end of the second year I started working in the music studio." (Always interested in music, he also sings with the Choral Society.) "It helped motivate me to get through school, because they were going to *use* my knowledge rather than test it. It was nice to see what I built in the lab put to use, when I was used to building something and then immediately tearing it down because other people needed the equipment."

William Lasser, '78

Bill Lasser is open, friendly, articulate. He explained his evolution of interests at M.I.T.: "When I started out, I wanted to be a professor of chemistry (I always liked academia). But after a year and one-half of chemistry, I felt it wasn't people-oriented enough. (I got sick of working in a lab — it was not a chance to be creative for me.) I was a cookbook lab person. It was challenging, but I didn't find it exciting. So I started to get interested in how science related to other things. The first non-technical thing I considered was law. Then I started thinking about public policy. I joined *The Tech* and got interested in journalism, until I decided I didn't want to spend my time just reporting on what others are doing instead of my own ideas.

"I went to Washington in the summer as an intern, and worked as a lobbyist, on DNA. By that time I had a double major in chemistry and political science. I decided I can be flexible with a Ph.D. in political science — I can teach, go into government, lobbying, or write columns (a nice way to get into political issues while using a science background)."

I asked about the environment here. "M.I.T. will not encourage you to do anything else if you are happy being an electrical engineer and nothing else. But if you get out and try to do other things, there is tremendous opportunity and encouragement — even if you are not great at it. Initiative is rewarded. Too many people think they need nothing else but a technical background — and there is peer pressure, a pride in taking 19 science courses. But technical issues can't be treated by themselves. The problem with taking 95 biology courses is the student doesn't get where his work fits into the rest of the world.

"You have to be an aggressive, outgoing person to make it here," he continued. "You have to know what you want to do and do it. When I chose a double major it caused some tension, but I knew what I wanted to do and people respected that.

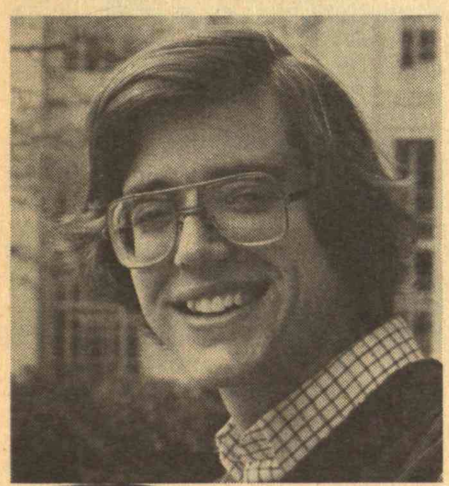
"I've been influenced to some extent in a negative way by the people here. They are the best chemists and engineers around — but I think they have a narrow perspective

on life. Their whole life is in the lab. In contrast, in the political science department they are interested in things based on human behavior and real life. They talk about Jimmy Carter and the way people react to various influences, not the way molecules react to other molecules. There is a larger picture. Not that energy research is not important — but I didn't want to be a cog in a machine where 50 people down the road solve some problem.

"An example is DNA. I would rather be on the political end, to look at issues and see how it works, than the biological end of it. I would rather have the Renaissance world view, to take into account aspects of philosophy, government control, freedom of research. Politics to me is a derivative science that pulls from history, art, science — all over — to come up with a solution.

"But I don't want to run for office. I wouldn't mind working behind the scenes. Congressmen spend too much time at dinners and luncheons and cutting ribbons. I'd rather work on the real problems."

I asked what was important in his experience at M.I.T. "The fact that M.I.T. doesn't have a journalism school and I had a chance to be editor of *The Tech* meant a lot to me. For the first time I was in charge of something — I had to make decisions that were in some sense important. It was a management situation — and in my junior year I was dealing with people (faculty and administrators) older and more experienced than myself. I used to be afraid to call up a professor. *The Tech* experience allowed me to talk to a professor on a completely different level than if it was about some paper that was due on Friday. And I no longer felt staff people were those I couldn't talk to. In other words, I grew up."



Jim Hawley, '78

"I was involved in research but realized I was more interested in management. The Undergraduate Research Opportunities Program project I was involved in was disillusioning; I didn't know what research was like. I thought it would be day-to-day excitement. But it's only after you have amassed the data and see the results that it's exciting.

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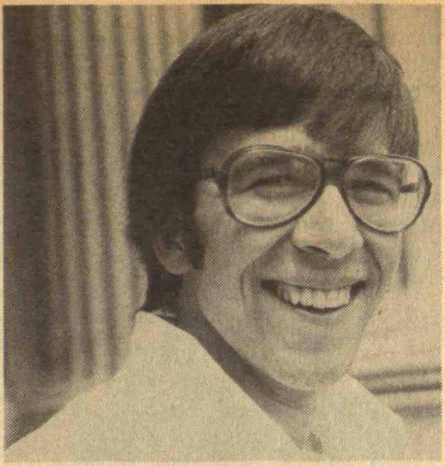

James L. Bidigare, Jr., '78

His genuine interest in people, quick smile, and gregariousness come through immediately. It is no surprise that he walks down the hall at M.I.T. saying hello to what seems like practically everyone. He's President of his class; he was Intrafraternity Conference Community Relations Chairman last year (and Secretary the year before); he writes a column for *Technology Review*; he's Captain of the varsity lightweight crew. It's called initiative.

"M.I.T. provides a lot of opportunity," he says. "I'm always looking for things where my input will improve something." (He wasn't kidding. I mentioned to him that we had an acoustics problem in the office and the next thing I knew he appeared with equipment to test a "white noise" background to change the atmosphere. It worked.)

Jim came to Boston from Detroit and fell in love with the city. But the social scene wasn't as good as his initial impression, he explained. "People here have been ostracized by their peers in high school because they were smart, and their self-image was based on academic performance. If they don't cruise through with straight A's they find problems. There is not enough effort made to address the more human aspects of school instead of brains."

On making friends: "I had no trouble. The problem is people are always waiting for the other person to say something. There is not enough recognition and response to other people. Part of it is a submersion in thinking while walking and eating. All it takes is someone saying 'hi' to change the atmosphere. M.I.T. students are really human and natural; they don't put on airs. But they have become good here in one small aspect of themselves, and a lot of other things were put on hold. It's hard to stay well-rounded here. Students get caught up in problem sets, tests, rather than in how to learn."

He says he has become fascinated with higher education and what makes it work. And he is intrigued with the function of a group acting toward higher ideals "where the final effort surpasses the sum of the individuals." Four years on the varsity lightweight crew gave him one opportunity to

"People here have been ostracized by their peers in high school because they were smart, and their self-image was based on academic performance. If they don't cruise through with straight As they find problems. There is not enough effort made to address the more human aspects of school instead of brains."

participate. He saw his experience as a member of a fraternity in a similar light — "striving for ideals develops a sense of ethics and humanitarian concerns."

For the future — at some point he would like to teach. "I like kids, I like their honesty." First, he will get a feel for what a career in architecture is like. Then — business school in 1980.

Beth A. Marcus, '79

"I can be involved in lots of things here I couldn't elsewhere. For instance, I don't have to be Miss Jock to be on an athletic team. I can have fun and not commit myself as an athlete."

~~370 First Ave~~
~~NY NY~~ 10010

When learning opportunities present themselves (like a paramedic course at Mass. General Hospital this summer) Beth eagerly takes them. And her aims are not small. One, for instance: to be an astronaut. Her credentials will be terrific when the next call for applicants comes, she thinks. (Last time she was not 21 and a college graduate, two of the necessary qualifications.) She hopes to be a licensed airplane pilot, knowledgeable in medicine, and possibly to have a graduate degree in biomedical engineering.

But there are so many possibilities. She was originally considering medical school, but decided that there is more room for creativity for the engineer who designs such things as a total knee prosthesis. A good engineer, she says, could rebuild the knee; a doctor is left with limited alternatives.

Her interests are wide: she spent one summer in Santa Clara, Calif., at the N.A.S.A. Ames Research Center doing research in space motion sickness. After her degree from M.I.T. she hopes to take time off with a Rhodes Scholarship to study archeology. Next spring she will take a Harvard Law School course — to see if law school would be a possibility. (That is an outside chance, though.)

About M.I.T.: "It's the best place I could have ended up because of the research opportunities. I can be involved in lots of things here I couldn't elsewhere. For instance, I don't have to be Miss Jock to be on an athletic team. I can have fun and not commit myself as an athlete.

"Since there are so many guys and fewer women, the men tend to treat women as friends. And I went from one extreme to the other — from an all-girls high school."

William L. Duke, '78

He talks about his plans for graduate school and an avid interest in geology with enthusiasm which is contagious. His manner is assured, friendly, warm, and intense. Bill Duke has known for a long time where his interests lie, and he has no hesitation in following a course of study directed toward research and teaching in geology. He specializes in processes occurring at the surface of the earth. "Dealing with things on a human scale, both in time and space — things that are real for all people," he puts it.

His interest began as a little boy in Ft. Worth, Tex., when he took walks with his father — a "rock hound," he explains. "I was amazed by the consistency of the rocks around my home — there was little variety in my environment, but I knew it existed elsewhere."

Bill will go to Hamilton, Ontario, next year for a Ph.D. program at McMaster University. He is looking forward to doing field geology in the Canadian Rockies (and quitting smoking) this summer, living in a tent and working on rock outcrops six days a week.

Social environment at M.I.T.? "Deep freeze, in general," he says. "People often leave as immature as they arrive, both socially and politically. When put together in a controlling environment, they don't grow. After four years of doing problem sets, they learned to think of life as a problem to be solved. And they become perfectly willing to solve any problem industry puts before them, even if the 'solution' represents a greater threat than the problem to the sanctity of life."

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Teresa Costanza Nolet, '78

"M.I.T. is not cold or unsocial unless you let it be. It's like something you do yourself. I didn't feel like I accomplished a lot in high school — but I've gone through here and feel I've really done something." (Her major is in materials science and engineering, and Ms. Nolet has just been named an honorary Ida M. Green Fellow.)

"In the Humanities Department I found a field I can play in — the history of art and architecture. It was interesting and very worthwhile. Wherever I go I can enjoy that.

"I went to an all-girls high school. People weren't serious about what they were doing. I wanted a place where people would be serious."

James J. Heeger, '78

Jim Heeger's first love is the violin. His interest in management (he will go to Stanford Business School next year) stems from his experience as tour manager for the M.I.T. Symphony Orchestra (he's a violinist) when they went to Lincoln Center in New York last April. And he was the Orchestra's President when they released their first recording.

"I've learned there is a certain amount of sobriety I have to maintain when running an operation. When I was a little kid I was stubborn and tempermental. But I found I can't work that way with people — and I've gone to the other extreme. Now people say I take everything calmly in stride."

There's a reason. "If you don't look like you're in charge you can lose control of a group quickly. On a trip such as the one to Lincoln Center in New York with the Symphony, we couldn't afford to lose control or make mistakes. It was a tight schedule — a two-to-three-day trip. The Council on the Arts gave me a free hand in getting things set up, and there was no big logistics mess-up (like leaving people stranded, which has happened in the past). Little things can ruin a performance; the musicians must give their best and they can't be worrying about details.

"The Orchestra allowed me to meet the performing side of M.I.T. Involvement in MacGregor House (as a member of the Freshmen Committee, Entry Chairman, President of the House last year and advisor and Judicial Committee member this year) allowed me to meet another side of M.I.T. — the Physical Plant and the Dean's Office. Now I can look at an organization as big as M.I.T. and see how people interact with each other."

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"I've learned there is a certain amount of sobriety I have to maintain when running an operation. When I was a little kid I was stubborn and tempermental. But I found I can't work that way with people . . . If you don't look like you're in charge you can lose control of a group quickly."

Nancy T. Lukitsh, '78

Nancy will go to Harvard Business School next fall after graduating from M.I.T. with a degree in earth sciences. Her interest in TV and communications management stems from involvement in M.I.T.V. It started as an I.A.P. project on how the media covered the presidential campaign. "We started in the New Hampshire primaries and taped how they taped the candidates. Then the project got more funding, and we went to Kansas City. It was a wonderful experience."

Nancy produced a program on M.I.T.V. called "M.I.T. Profiles," a series of hour-long interviews with members of the faculty — Professors Edgerton, Samuelson, and others. "I feel that these people are a vital part of M.I.T. They have important things to say and interesting experiences to relate to the M.I.T. community. M.I.T. has a rich history that these people helped to shape. 'M.I.T. Profiles' was my attempt to record that history."

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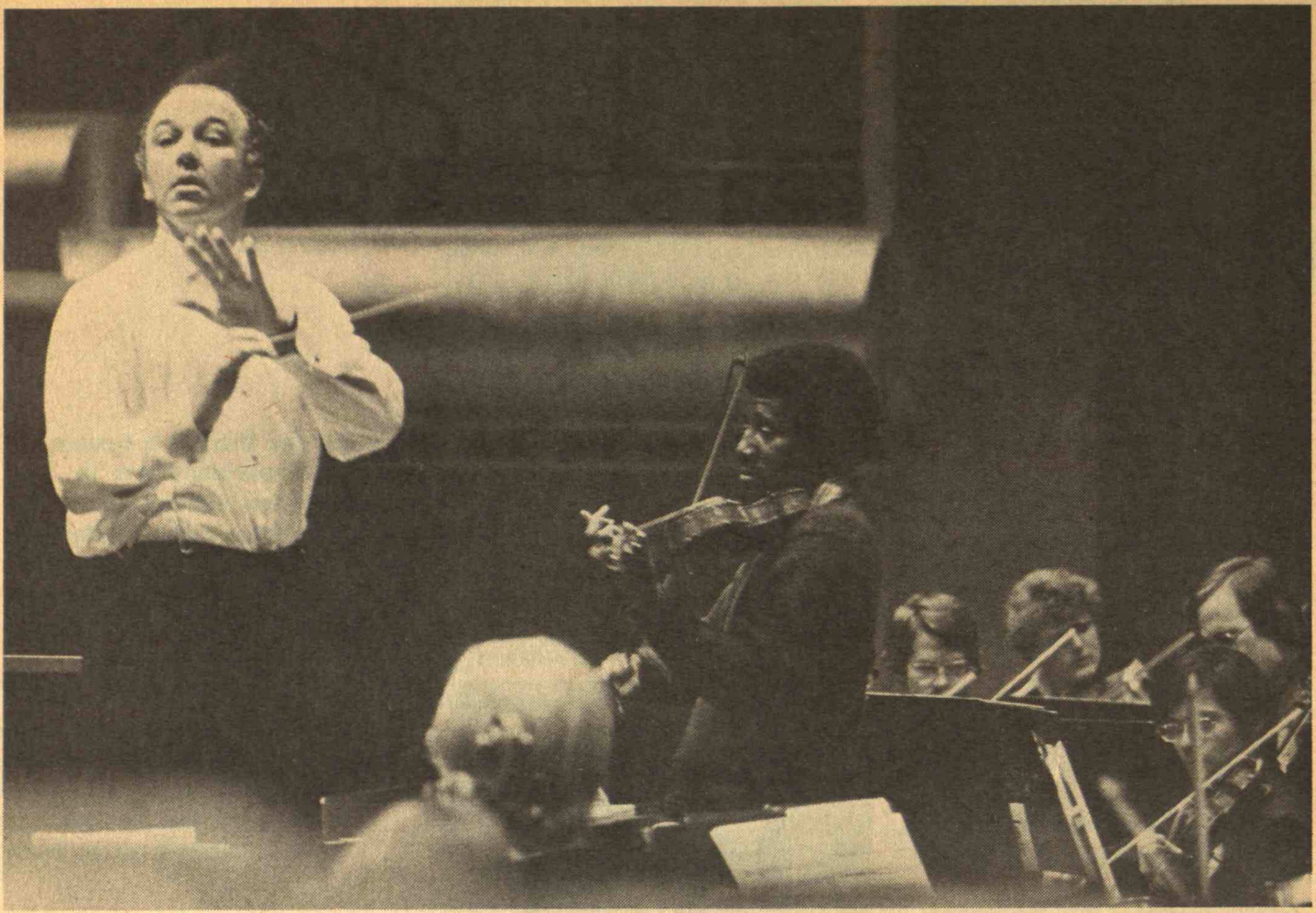
Garden City NY
11530



At Lincoln Center, the Clarinetist "Felt Like Jumping Out of My Chair"

For thousands of young musicians across the country, playing a concert in Avery Fisher Hall at Lincoln Center — home of the New York Philharmonic — would be the dream of a lifetime.

It happened on April 12 for the 95 musicians of the M.I.T. Symphony Orchestra — with an extra thrill when the full house for their concert responded with a standing ovation.

The Orchestra began its annual spring tour at Wellesley on April 10; it was the first time the musicians had played with Professor Marcus Thompson — who was viola soloist in Berlioz' "Harold in Italy" — in more than two months, since Professor Thompson was on leave for the spring term. The Orchestra admits the Wellesley event was "more of a rehearsal than a performance."

But next came a stop at Smith College in Northampton, where the evening was described as "superb."

And then on to New York.

"We were really very excited about this one," says Howard M. Schnapp, '79, President of the Orchestra.

First came a one-hour "warm-up" rehearsal in Avery Fisher Hall, devoted mostly to discovering acoustical differences from the Orchestra's home base — Kresge Auditorium. The brass section, which plays extra loud in Kresge because the hall is so sharp, had to tone down some, and the cellos found they had just the opposite problem.

As the session ended, Conductor David M. Epstein, Professor of Music, warned the players about overconfidence from "knowing the music too well. . . . Concentrate intensely on the music — and on me," he said.

When the time for the concert came, the musicians obviously did just that. Indeed, their calm professionalism was evident near the end of "Harold in Italy," when the E-string of first violinist Arthur Hu, '80, broke. His solo passage was immediately and smoothly assumed by co-concertmaster Daniel U. Yuan, '80.

"Exhilaration" was the word Mr. Schnapp, a clarinetist, chose to describe the feelings of the group at the end of the concert. "I felt like jumping out of my chair," he recalls.

At a lobby reception after the concert, M.I.T. officials and many alumni and other patrons of the arts at the Institute from the New York area greeted the players. Conductor Epstein was mobbed with congratulations and signed dozens of autographs. Also present as invited guests were more than 200 newly-admitted applicants for the M.I.T. Class of 1982 who took advantage of their chance to talk with Orchestra members.

Freshman violinist Samuel L. Hurt summed up: "It was a really good time — probably the best concert this year."

While all this was going on, Orchestra pianist John E. Kirsch, '79, was exploring backstage, where he found no fewer than six nine-foot Steinway concert grand pianos. He couldn't resist the temptation to try one: "It was the finest piano I've ever touched," he says. — *Joanne Miller*

The M.I.T. Symphony Orchestra had just an hour to savor the intricacies of Avery Fisher Hall during a "warm-up" rehearsal with Professors David M. Epstein and Marcus Thompson (opposite) before a standing-room-only concert on April 12. But it all came out well enough: "Discipline is the hallmark of the Orchestra," wrote Raymond Ericson of the New York Times. (Photos: Roger N. Goldstein, '74)

An Ensemble with "Discipline" — "Smartly" . . . "Skillful" . . . "Sparkling"

Here is how Raymond Ericson, music critic, reviewed the M.I.T. Symphony Orchestra's concert in Avery Fisher Hall on April 12 for the New York Times *(April 14)*:

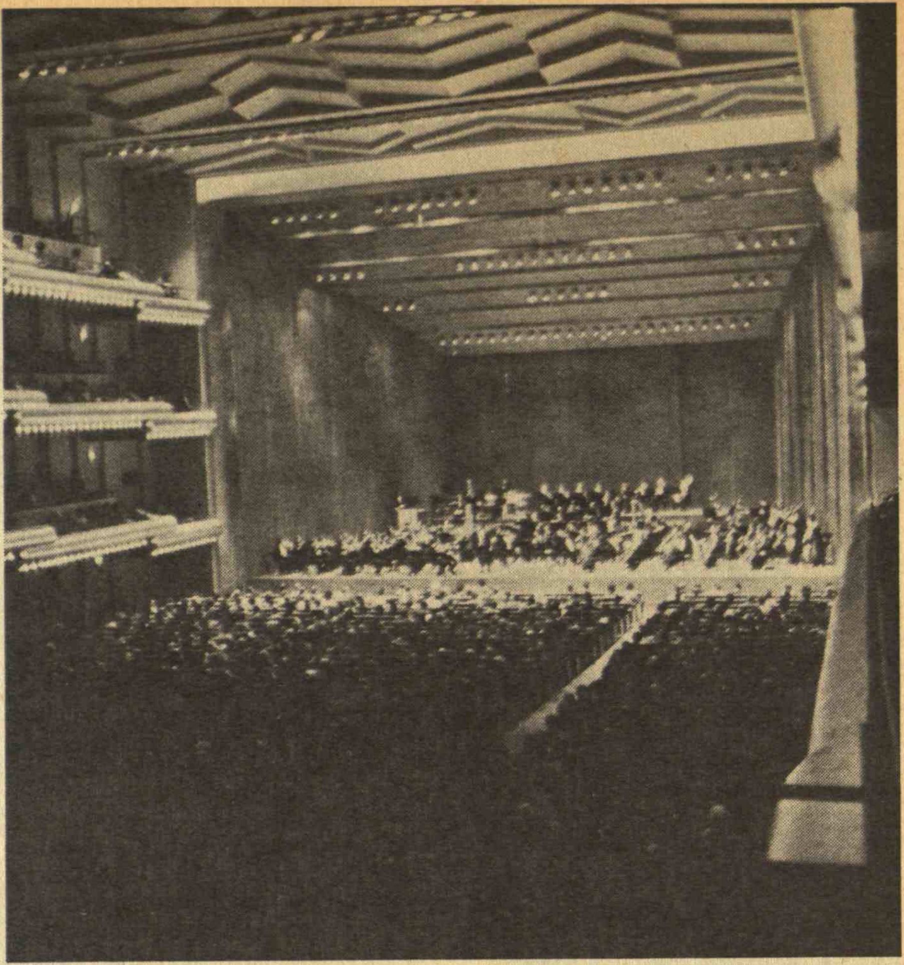
Discipline seems to be the hallmark of the playing of the Massachusetts Institute of Technology Symphony Orchestra. It was evident in its two previous appearances here, and was an admirable element in its concert in Avery Fisher Hall on Wednesday night. Still under the direction of David Epstein, the ensemble performed smartly in a program that included Stravinsky's "Scherzo a la Russe," Kurt Weill's Suite from the opera "Silbersee," and Berlioz's "Harold in Italy."

The Orchestra, 95 players strong, showed how skillful its wind sections are by sparkling through the dry wit of Stravinsky's bit of native color. The strings added luster to the Weill Suite, which was being given its New York premiere. This is a particularly beguiling work that ought to find a place in lighter symphonic programs.

One of Weill's European works — the librettist was Georg Kaiser — "Die Silbersee" was not turned into an orchestral suite until 1947, when the composer, after several years in America, had softened his satirical style considerably. The suite has remnants of his sharp "Threepenny Opera" manner, but these are overshadowed by a bittersweet lyricism. One suspects that the original orchestration was more pungent. In any event, the section called "Das Lied vom Silbersee" and the Finale, with its seductive waltz, are beautiful and the whole suite should become popular.

Mr. Epstein did everything right in the Berlioz, as did Marcus Thompson, the viola soloist. Yet the performance was curiously tame. "Harold in Italy" is not one of the composer's liveliest or most dramatic works, it is true, but opportunities for special accents and rhythmic devices to give the music tension and imagination were not taken.

Mr. Thompson, an elegant violist, was rather too gentlemanly as the Byronic protagonist, and his tone tended to be outweighed by that of the Orchestra. One could honor the entire Berlioz for its discreet accuracy, but it never got off the ground.



Raymond Ericson, music critic of the New York Times, *said "the ensemble performed smartly." A student member of the M.I.T. Symphony Orchestra said it was "probably the best concert this year." Another "felt like jumping out of my chair" when it was over. The audience gave the performers a standing ovation. Everyone was excited when the M.I.T. Symphony Orchestra played in Avery Fisher Hall at Lincoln Center, New York, on April 12. (Photos: Roger N. Goldstein, '74)*

03

I and all classmates rejoice for a charming letter from **Charles B. Cox** at his new address: 1200 Madison Ave., Wenatchee, Wash. He is alive, active, and walks daily for exercise.

There is another unpleasant vacancy in our memorable classmate group. **Clarence M. Joyce**, 619 Chia Rd., Palm Springs, Calif., passed away at home on February 9, 1978. — **John J. A. Nolan**, Secretary, 13 Linden Ave., Somerville, Mass. 02143

12

Had a nice letter from **Ham Merrill**. Ham and Phyllis are both "healthy, happy and busy." This should be a pretty good combination. Their activities cover quite a wide range of interests: Phyllis with church, hospital, garden club, women's club and bridge; while Ham is busy with SCORE, historical society, conservation and local politics as well as bridge. They have been moving about a lot lately: to Maine for the wedding of a granddaughter, to Illinois for the wedding of a grandson, and more recently to Connecticut where 20 members of the family gathered to celebrate Phyllis' 80th birthday. Congratulations Phyllis and many happy returns.

Harold Brackett has been in the hospital with pneumonia and complications. He has recovered from the pneumonia but didn't enjoy the hospital food. He lost weight and is now home recuperating and getting some home-cooked food preparatory to another bout at the hospital. We have had some experience with Eleanor's wonderful cooking and are confident that Harold's weight loss will soon be history. Good luck Harold, we hope your next trip to the hospital won't be serious, and that the food will be better.

Jonny Noyes must be home, because I couldn't get him at the hospital the other day when I phoned.

I also called **Louis Flett** at Gloucester. He is up and around. The phone connection wasn't too good so I didn't hear all he had to say. It was nice to talk with him.

Your secretary and his wife Julie had planned a trip to Florida but, between our Indiana blizzard and a couple weeks in the hospital by yours truly, we had to cancel. I am back to normal except for some weight loss. We were snowed in at the hospital and I just got too many powdered eggs, that's all. We expect to start our postponed trip in a couple weeks. Katherine and **Paul Tyler** have invited us to stop off at Holmes Beach on our way south and have cocktails with them. We couldn't turn them down and are looking forward to seeing them. We expect to spend some time at Clearwater Beach and will return via the East coast, visiting some friends along the way and stopping at Richmond, Va., to visit our daughter. — **Larry Cummings**, Secretary, R.R.4, Connersville, Ind. 47331

13

It has been some time since we had notes in the *Review* due to various circumstances, but now offer several short notes and comments sent with dues which may be of interest. **Fred Lane** writes: "Your reference to the Alumni Day Luncheon in June, 1978 makes me sigh. Looks like I might have to miss it." From **J.B. MacNeill**: "We enjoy your notes. Good luck and keep well." **David Stern**: "Hope you and Roz are well." **Charles Albert Smith**: "Have no expectation of getting East this year." **Joe Isenberg**: "Best wishes." **Kenneth D. Hamilton**: "Glad to hear from you. I'm still going strong but cannot run 100 yards in ten seconds." **William G. Horsch** writes: "No particular news at this time. Have not been to Newburyport for more than two years. Our best to you both from Gertrude and me." **Bion Pierce**'s wife "Bunny" writes: "We do hope to make it in June. Bion is not too active but is able to be up and about each day. Only made one trip to Maine this year."

Walt Muther challenges **Tom Lough**'s statement that he is the oldest living member of the Class of '13 (see December, 1977, notes). Walt says he was born on March 1, 1890, so he is already 88. He goes on to say that in spite of his "old age aches and pains" he still expects to attend the 65th Reunion. Our congratulations to you, Walt.

We are sad to report the deaths of two of the most loyal and respected members and former officers of the Class. **Ellis W. (Bill) Brewster** died March 17 after a long illness. He was Chairman of the Board of the former Plymouth Cordage Co., having begun his career in the plant's sales department. He retired in 1957 after 40 years with the firm. A descendant of Pilgrim elder William Brewster and a lifelong resident of Plymouth, Brewster was a director of the Plymouth Home National Bank, a trustee of the Plymouth Five Cents Savings Bank, a director of the State Street Bank and Trust Co., and a member of the executive committee of New England Telephone and Telegraph Co. He was also a trustee and President for 22 years of The Pilgrim Plantation, a member of the M.I.T. Corporation and the Mayflower II Reception Committee. He was a charter member of the Plymouth Rotary Club and a member of the Old Colony Club, the Eel River Club, The Society of Mayflower Descendants, The Colonial Society, The Bostonian Society, the Massachusetts Historical Society, the Union and Commercial Club of Boston, and of First Parish Church in Plymouth. He leaves his wife Ellen, five children, 21 grandchildren and 11 great-grandchildren. We have sent a donation from the Class to the First Parish Church of Plymouth in memory of Bill, as was his wish.

Henry O. (Heinie) Glidden died March 16. He was a retired architect for the Turner Construction Co. and a well-known watercolor artist. Heinie was elected Class President at our 60th Reunion. He was a member of the First Church of Christ, Scientist, Columbian Lodge AF and AM where he received a 50-year membership medal, and the founder and first president of the Abington Art Association.

In 1963 Glidden received the Richard Mitton Memorial Award in recognition of his paintings. He also was a life member of the Appalachian Mountain Club. He leaves his wife Jane and two daughters. We have sent a donation to the M.I.T. Alumni Scholarship Fund from the Class in memory of Heinie as he requested.

We have received a notice that **Frederick H. Kennedy** died on August 21, 1977. No other details.

Allen Brewer, one of our most faithful correspondents, had written some time ago that both he and Maurine were well although Maurine had a bout with pneumonia and he was bothered with arthritis. He writes, "Hi, Phil: I've just noted in the latest issue of *Tech Review* that you were a 'guest' of the hospital a few months ago. The note reported you were doing O.K. now. Glad to hear it. Hope your session under medico's care did not prove to be too serious. Be careful because we are looking forward to seeing you and Roz in Cambridge next June.

"I received **Frank Achard**'s information as to our reunion plans a few days ago. I'll be answering him noting that we both 'hope' to attend. I'd say we 'plan' but in these devious times of our 65th school year and my personal 'over 85' age, I hesitate to say anything too positively. But, sincerely, we do plan to come if the roof 'don't fall in.'

"Our winter down here has not been too bad. Had our share of the bad weather, but nothing to compare with yours in the North. Temperatures were in the low 40s for quite a time, but the fuel held out, and we used a few sweaters. Now we are going through the spring tornado season. We just had an alert this morning — false alarm. We had some nice rain, which we needed for setting the fertilizer we had spread on the lawn a few days ago. Lately I've been 'waxing poetic.' I wrote a few verses for our local newspaper which the editor was kind enough to use. We both keep passably well. Me, as I've told you before, I'm just like 'Old Man River.' But with the aid of my cane I don't let things bother me, although arthritis is sometimes bothersome, especially when I get up after sitting too long.

"After the reunion one of my grandsons hopes to get his Eagle Scout rating in Braddock Heights., Md. Another bit of news: I'm now a great-grandpappy for the fourth time. Now it's two girls and two boys. Remember us to Roz and take care of yourself."

We occasionally receive nice notes from **Charlotte V. Sage**. She faithfully attends all Alumni affairs.

Look forward to next month's *Review*. — **George Philip Capen**, Secretary and Treasurer; **Rosalind R. Capen**, Assistant Secretary, Granite Point Rd., Biddeford, Maine 04005

14

Harold S. Wilkins accepted in April the appointment by our Class President, **Alden Waitt**, of Vice

President and Treasurer. It's good to have again an officer who lives near Cambridge and so can represent us in person at the Institute.

Walter C. Eberhard died at his home in Waltham on February 13, 1978, at the age of 85. He was a member of our class in all our undergraduate years and received his bachelor's degree with us in Course I. After naval service in World War I, he joined the teaching staff of the Institute in 1919 and remained on it until his retirement as an assistant professor in 1957. Walter is survived by two sons, Walter S. Eberhard, '42, of Towanda, Penn., and Kenneth M. Eberhard, '47, of Colville, Wash.; and a daughter, Mrs. Robert (Jean) Hughes, of London.

James F. Morgan died on November 28, 1977. He was with us in our first two years, and lived in Honolulu. Information on his career is being sought for the class notes in a later issue. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

You're a great bunch of classmates. Many thanks to you all for the many messages, visits and calls you have made to me while I have been laid up. It's made me feel good to hear from you. I'm not sick, but hobbling around on this cane (although better than the wheelchair of last summer) is still tough.

Jerry Coldwell is retired quietly in Bronxville and no longer goes downtown in Manhattan. . . . **Phil Alger** made an addition to his autobiography unit — *More Tales of My Life and My Family*. It is interesting reading. . . . **Alton Cook** visited his family in Yorbra Linda, Calif. He plans to see me here in June, and we can discuss our troubles with "old age." . . . **Bill Brackett** has been badly crippled at his home in Duxbury, Mass., but has made a brave and determined fight to keep going. All the best, Bill.

It is good to see **Otto Hilbert** still busy doing historical research for his company — the Corning Glass Co. He writes: "It is nice to again see so much news about those who used to chase around Copley Square so hurriedly between classes many years ago. I have a picture of our 1955 and 1970 reunions which I would be glad to send to you to pass on to anyone who might want them." . . . **Clive Lacy**, **Wally Pike** and I visited with **Archie Morrison** at his nursing home. . . . **Jim Tobey** has returned from a cool, rainy winter in Florida to "suffer" in Rye, N.Y. "I returned to Rye on April 1, the fools' day, after three months in Florida. It was 80° on my arrival at Kennedy, but it has not been very spring-like since. The weather in Florida in January and February was not too ideal either, but it was a lot better than Rye or Cambridge. March was about 80° regularly." . . . I've talked with **John Dalton** and from his letter, he is enjoying his retirement. He plays duplicate about once a week. Nice going, John.

Wayne Bradley spends one night a week with me and has been busy getting his place, Moosalaukee Inn at Waren, N.H., ready for the coming summer season. . . . We welcome back one of our staunch and loyal classmates, **Whit Brown**, who must have had a tough time at his retirement place in Florida. "Our luck ran out last October in Anna Maria. Marjorie had an emergency gall bladder operation that was done just in time. Then while she was in the hospital I came down with viral pneumonia — so we were both in the hospital." . . . He has now recovered and is living at Decatur, Ga. I am glad to have Whit's good letter for I missed not hearing from him at Christmas.

Harold R. (Brute) Crowell died January 26 in Los Angeles. . . . **Charles W. (Speed) Williams** died March 19 in Westport, Conn. The sympathy of our Class goes to these two fine classmates. — **Azel Mack**, Secretary, 100 Memorial Dr., Camridge, Mass. 02139

16

This is being written before our 62nd Reunion and will be read after the event. As we approach it, the indications are for a pretty good turnout. In soliciting attendance, we had responses so far from at least 60 of our classmates. **Frank Holmes** writes: "Expect to be in the Phillips House of the Mass. General Hospital. Will look forward to another year." **Harmond Keyes**: "Thanks, but due to distance cannot attend." **Hank Smith**: "I am very sorry indeed that I will not be able to attend the reunion again this year." Cy and **Gypsy Guething** would "love to attend but cannot make it." **Ken Sully**: "Have a good reunion." **Frank Darlington**: "Ill health prevents." **Shatswell Ober**: "Best regards to you and all."

Allen Pettee writes: "Being probably your worst correspondent, I hasten to give you my new address in Tryon where we lived for 16 years before we moved to the mountains to be near a nursing home. Now that Tryon has its own nursing home close by apartments, we are back-tracking to what appears, currently at least, to be greener pastures, practically in the center of Tryon. This will allow me for years to walk anywhere in the business district." . . . **John Gore** writes: "Sorry I won't be able to make it to Chatham this year. It's a long pull from here to there, and at 84 I don't feel like making it. Please say 'Hello' for me to the rest of the gang."

Theron Curtis writes that he can't say whether they can make it to the 62nd Reunion. "Give our best wishes to the gang, have a happy time and keep breathing." His wife Hope is in the process of recovery after a long stretch of illness. . . . From **John Fairfield**: "Gosh, this hurts — to say no. No news here; busy reading about the American Revolution. One thing leads to another — you get one book and need another to check and compare. New England and New York affairs have so many reminders as one travels that the facts remain vivid; whereas events in the Carolinas are vague. Was Kings Mountain in South Carolina or North Carolina? In what year? And what was the result?" . . .

Dina Coleman writes: "I took a flyer last month down to Panama and Peru and got an eyeful in both places. Apparently those people have lived under military dictatorship so long that it's just a way of life for them." . . . **Francis Stern** writes that he and Gladys have returned to their home in West Hartford after wintering in Palm Springs. In July Francis is scheduled for another eye operation. . . . I also heard from **Jap Carr**, who continues to work effectively as our Class Agent. We're fortunate to have him in this important role.

Vic Dunbar writes: "The Class of 1916 appears to have adopted me as a member since I attended the summer of 1913 and the following year at M.I.T. after graduating from Dartmouth in June 1913. I considered both Harold and Len, and later their wives, very friendly, Harold, Len and I each loved Lake Winnipesaukee, N.H. I have started a review of sorts of my connection with M.I.T. to mail you, but since I had a stroke I tire quickly. I have always been so healthy that it is difficult to have to rest so much.

Finally, we regret to report the passing of **Earle Pitman** last February. A graduate of Harvard College and M.I.T., he became a chemical engineer and helped develop nylon and smokeless gunpowder. His inventions also include a method of joining parts of a shoe without using stiches and a patented method for smoothing the outer surfaces of an aircraft to reduce air resistance. He was a Fellow in the Institute of Chemists and in 1940 received the Modern Pioneer Award from the National Association of Manufacturers. Keep writing and keep breathing. — **Ralph A. Fletcher**, Acting Secretary, P.O. Box 71, West Chelmsford, Mass. 01863

17

Win Swain and his wife, Lib, have given up their 483 acres in Virginia and are back at 4 Leavitt St., Hingham, Mass. In Virginia, they were landed "Virginia squires," growing and marketing tobacco, grain, lumber, and pigs; they processed their own wine and supplied it for their own church rituals. They also incorporated a swimming pool into the estate, designed by one of Win's M.I.T. buddies. At Hingham, they will presumably live simple, conventional lives, as do most of us. Win has withdrawn from some, though not all, of his interesting investment explorations and aid to small, growing companies.

Tubby Strout is home after a stay in the hospital for some undiagnosed ailment. His wife, Ruby, also has recovered pretty well from her illness; she gets around with the use of a cane and can drive the car — which helps a lot, as Tubby cannot as yet do so. His grandson, William S. Dunbar, is studying at M.I.T. for his doctorate; he was recently selected to attend a seminar at Endicott House with government and other officials on the subject of energy.

John Holton and Sally have returned from Florida and are now busy getting their big house in Skanaeteles cleared out and sold in preparation for moving to their retirement house at Folkways in Gwynedd, Penn. . . . **Frank Peacock** is looking forward to our fall reunion in October. Frank's son, Nikolas, has been in Tokyo for two years working for a subsidiary of Union Oil Co. Frank talked recently with **Al Litchfield** and **Dutch Neumann**, and both intend to attend our October reunion.

Stan Dunning has finalized arrangements for our reunion on October 10, 11, and 12 to be held at the new Sheraton Inn at Old Sturbridge Village, which is a recreated New England farming village of the 1970-to-1840 period. The 200-acre village consists of nearly 40 original buildings moved from different sections of New England to the site. Horsedrawn vehicles provide the only transportation. The Sheraton Sturbridge Inn is located close to the entrance to the Village. Sturbridge is near the junction of the Massachusetts Turnpike (I-90) and Interstate 86. Arrivals are expected at noon on October 10 and departures the morning of October 12. Detailed information later.

Marion and **Les Ford** spent the winter in Venice, Fla., "for rest and a chilly relaxation." Les says they now have six grandsons, one granddaughter, and one great-grandddaughter. Their grandson, James Bryant, recently won the English Speaking Union scholarship, entitling him to spend a year in England. On his return he will attend a college in the States, where he already has several acceptances. Les and Marion continue their interest in the New Bedford Whaling Museum and the Waterfront Historic Area.

Don Severance, '38, recently on a West Coast trip, had breakfast with Helen and **Jack Wood**. Helen and Jack both sail whenever they have the opportunity. . . . Dorothy Gardner, widow of **Hartley Gardner**, writes that Hartley died on February 8, 1978, after being a semi-invalid for several years. Dorothy continues to live with her son and his wife in Bethany, Conn. . . . **Ray Gauger**'s widow, Ruth, writes from St. Paul that in 1972 Ray was injured while walking across Fourth Street on his way to the Athletic Club for lunch. Following surgery on his hip, he was never able to walk without the use of two canes. On May 6, 1977, Ray died in his sleep. Ray had established an architectural business with a Mr. Will Parrish, who became his partner. Now Ray's younger son, Glenn, shares the ownership with Mr. Parrish, in Gauger- Parrish, Inc.

Notice has been received of the death of Betty Hulburd, widown of **Phil Hulburd**, on April 7. Phil was chairman of the Mathmatics Department at Philips Exeter Academy for many years. . . . We regret to report the sudden death of **Alfred Ferretti**'s wife, Laura, on April 14. Laura was a very faithful attendant at our reunions and we all have fond memories of her. Our sympathy goes out to Al for his loss of Laura.

We deeply regret to report the sudden death of **Richard O. Loengard** on April 1 and extend our profound sympathy to his widow, Marjorie, two sons, one daughter, and five grandchildren. Our Class was represented at the memorial service by Pat and **Bob Erb**. Dick was one of our class stalwarts, a Vice President and later an Assistant Secretary for many years. He was a prime mover of the monthly luncheons for the New York and New Jersey alumni from the classes of 1916 and 1917 at the Chemists Club. For years, Dick was President of United Chromium, Inc., and he was

also active in civic affairs — having been, at his death, Chairman of the Board of Managers of the Jacob A. Riis Neighborhood Settlement. He had served for 50 years on the Board.

Also, to our sorrow, we must report the death of **Raymond Blanchard** on April 1, after an illness of several years. Ray had a very active business career (he was the retired President of the Hood Rubber Co.) and had also been active in community and business groups — a former President of the M.I.T. Alumni Association, the Associated Industries of Massachusetts, the Melrose-Wakefield Hospital, and the Bellevue Country Club of Melrose as well as former Chairman of the Board of the First National Bank of Malden. He is survived by his widow, Evelyn, a daughter, a son, a sister, and six grandchildren and two great-grandchildren. The deep sympathy of the Class goes out to Evelyn; the Class was represented at Ray's memorial service by Katherine and **Ray Stevens** and **Stan Dunning**. Vincent Fulmer and Robert Blake represented the M.I.T. Corporation and Alumni Association. The large church was crowded — a great tribute to Ray's memory.

We have also received news of the death of **Frank N. Crane** of Carmel, Calif., on December 16, 1977. For many years, Frank was with the Bureau of Engineering of the City of Los Angeles.

Bob Erb and Pat have had a winter vacation. Starting at San Francisco, they cruised down the California coast, the Mexican coast, and through the Panama Canal and the Caribbean to Ft. Lauderdale. Then they enjoyed a week in Florida before coming home to Connecticut. "As always," says Bob, "glad to be home". — **William B. Hunter**, Secretary, 185 Main St., Farmington. Conn. 06032

18

(Correction: Information reported about Clarence Keller in the May issue should read **Clarence Fuller**. — S.K.)

The lot of being your Secretary and publishing these notes for you is subject to peaks and valleys. This month is one of the low points, for there is a dearth of news.

Selma and I just returned from a week's trip to Williamsburg, Richmond and Washington. We were part of a group sponsored by the Boston Museum of Fine Arts with a lecturer from its staff as our guide. We were thus able to visit some unusual exhibits not readily available otherwise. We saw and learned much — the history of Colonial times, its architecture and its fine furniture and decorative arts. In Washington I chatted with **Bill Foster** who is "weak but willing" and with **Al Murray**, active as an investment counselor. They both regret they cannot be with us for our 60th. We also had a most pleasant breakfast visit with Frances **Harrall** who reported that **Pete**, though still in the hospital, is making slow progress.

You have all received mailings concerning our 60th Reunion in June — hopefully we will have a good representation. The program is tailored to make it most interesting and enjoyable. **Jim Bugbee** is making the trip from California, which may make him the prize winner for coming from the greatest distance. Hopefully, **Jorge Pena Polo** will be with us from Cali, Colombia, South America — maybe Jim will lose this crown to Jorge.

We note with regret the passing of Mrs. Marion C. Kenney on December 30, 1977. — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 599 Washington St., Brookline, Mass. 02146

19

We have just learned from **Donald D. Way**, Class President, of the death of **Eugene R. Smoley**, Secretary of the Class of 1919 for nearly 60 years, on May 2, 1978. He will be greatly missed by the Institute and by the surviving members of the Class. **W. O. Langille** has agreed to accept the post of Secretary, and any class news should now be sent to him at P.O. Box 144, Gladstone, N.J. 07934.

Mr. Smoley submitted the following notes before his death:

"Word has been received of the death of **Ernest L. Schwartz** on January 1, 1978. Ernest lived in Franklin, N.H. He worked for 25 years at the Bell Telephone Laboratories in New York City, retiring in 1944. He was a 32nd degree Mason and a member of the Shrine Order of Eastern Star. . . . **Francis D. Porcher** writes that his son Tom graduated with a B.S. from Stevens Institute in 1975.

I have further information about **Howard McClintic, Jr.**, whose death was reported in the May notes. Howard was a retired vice president of the McClintic Marshall Co. The company did construction work on the George Washington and Golden Gate bridges. Later he was Chariman of the Ferguson and Edmundson Co. of Pittsburgh. He served in the Army in World War I and in the Navy in World War II. Sam Grooves, a friend, writes, 'What the obituary omits is what a sensational character he was. Nicknamed 'Boom Boom,' he was always amusing, pleasant, irreverant and popular. He was a proud graduate and an ex member of the corporation.' " — S.K.

20

Welcome word from the sunshine state comes from those stalwart members of the Class, **Ed Burdell** and **Dolly Gray**. Ed continues active service to the community of Martland, Fla., through a series of talks on how to keep well, and if you can't, how to make the best of it. Dolly avers that he is "living quietly in the Florida sunshine." Remembering how active and up and coming he was as an undergraduate we can scarcely imagine him living quietly. His address is Harland A. Gray, 4425 Coco Ridge Cir., Sarasota.

I am indebted to **Ed Ryer** and Harry Ramsay, '21, for passing the word on the death of **Roger McNear** of Tucson, Ariz. Roger left Duxbury for Tucson ten years ago for health reasons. He was Vice President of U.S. Rubber Co., and before retiring, was Managing Director of North British Rubber Co., a subsidiary of U.S. Rubber. He lived at 6731 St. Andrews Dr. In appreciation of Tucson's healthful climate, he was active in the community, serving as director and former Vice President of Skyline Country Club and a member of the Arizona University Foundation. He is survived by two grandsons. In World War I he served in the U.S. Navy. His undergraduate days were cut short by war service, but many of us will remember Roger with warm affection. He was a loyal member of the Class.

Ed Ryer also reports on the death, last fall, of **Scotty Wells** at his home in Louisville, Ky. After his retirement he lived for a time in Clearwater, Fla. In business he was active in the granite industry in New England. A widely known and popular member of the Class, he was a leading spirit in many class reunions. His absence will be felt by us all. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

Special tribute was paid to our classmate, **Manuel Sandoval Vallarta**, on March 6 in Mexico City. Sandoval died in April, 1977. A copy of the tribute was mailed by Clarence Cornish, '24, to **Irving Jakobson**, and passed along to your secretary. Dr. Vallarta became a world famous scientist who received many honors. He taught at M.I.T. from 1924 to 1946 and became a full professor of physics. As Mexico's Chief Representative, he was elected President of the United Nations' Atomic Energy Commission in 1946. Again in 1968 he was elected President of the International Atomic Energy Commission meeting in Vienna.

Quoting from the tribute: "A very happy and fortunate event occurred in his life in 1931. During a visit to his homeland, Dr. Sandoval met a beautiful, intelligent and bubbling young lady, the daughter of a famous physician and man of great culture, Dr. Cesar R. Margain. He seems to have been as swift in his courtship as in his acquisition of knowledge, for he married Maria Luisa Margain and whisked her off to Cambridge. She became his constant companion, his devoted admirer and his link with people in general."

The Mexican-North American Cultural Institute meeting on March 6 was the occasion for the tribute. Among the speakers was Julius A. Stratton, '23, President Emeritus of M.I.T., who recalled his long comradeship with Vallarta. Said Stratton, "He was a brilliant, inspiring teacher, extremely popular with students, and my own debt to him is enormous. He first revealed to me the excitement of physics and stirred my interest in electromagnetic theory, which was to become my special field." The class salutes this brilliant scientist.

A letter from **Irving Jakobson** in late March tells of "a lovely two weeks of cruising amongst the Virgin Islands. Warm weather, good breezes, good sailing and swimming. Wish I could spend the whole winter there especially if the weather up here is going to repeat itself."

A postcard from **Bob Miller** mailed from Mexico says "Helen and I had a memorable luncheon yesterday (March 8) at the famous Jan Angel Inn with Graciela and **Helier Rodriguez** and Helena and **Viviano Valdes** who were the hosts. After the luncheon we all went to the beautiful Valdes home in Coyocan. The Rodriguezes leave today on the Fiesta trip. We are flying to Orlando, Fla., next Monday and then return home on March 15."

Sadly we report three more deaths: **Joseph G. Kaufman** of Southfield, Mich., on February 15, 1973; **Alice Bronfenbrenner** of St. Louis, Miss., on September 17, 1977; and **Albert H. Wechsler** of Boston, Mass., on February 28, 1978. Joe Kaufman became President of the Joseph G. Kaufman Company in Boston. During her business career Mrs. Bronfenbrenner was a chemist for Lambert Pharmaceutical Company and resident chemist at Washington University Medical School in St. Louis. Al Wechsler worked for the U.S. Coast and Geodetic Survey after graduation and then joined Converse Rubber Company in 1928. He retired in 1967 as President of Converse Rubber. The sympathy of the class is extended to their families. — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

The vacationers returning from the Southland are bemoaning the fact that the weather was erratic — but there was no snow to shovel. Our tennis players and golfers simply dressed after the reading on the thermometer. Ruth and **Yardley Chittick** report a pleasurable time at Fort Myers and Captiva Island, Fla., by sending a beautiful view of the area. . . **Oscar Horovitz** and **Frank Kurtz** on the East Coast and **Parke Appel** on the West Coast note that the warming trend finally arrived in April.

Your Secretary has been reviewing the pleasant color slides of last June's 55th Reunion at M.I.T. and at the Spalding Inn. Club in N.H. We regret not seeing all of you again this year under such pleasant surroundings. Let's hope for an equally pleasant 60th Reunion.

A letter from **Samuel H. Reynolds**, 2150 Mar East St., Tiburon, Calif. 94920, tells that he has moved from Madison, Conn., to be near his grandchildren. Sam keeps busy as Chairman of the Score Chapter in San Francisco with 150 counselors helping small businessmen. He is finishing ten years of volunteer work for this important organization. Sam says that he has given up golf but swims everday to keep in shape. . . . **Ed Merrill** is still in that general area.

We are pleased to read of **Horace W. McCurdy** as the principal speaker for the annual meeting of the Seattle Historical Society at the Museum of History and Industry on April 26, 1978. Included in their invitation is a picture of Mac (age 6) on the dock of the large sailing vessel *James Tuft* with the announcement of the "most noted speaker on maritime and early historical matters in the State of Washington." It is really dispointing that more

U.A. Whitaker's Fund Takes Its Founder's Name

The Health Sciences Fund, established in 1974 to support medical research performed by Boston-area institutions in association with M.I.T., has a new name and a somewhat expanded mission.

It's now the Whitaker-Health Sciences Fund, in honor of the late Uncas A. Whitaker, '23, who founded the Fund as a part of his untiring support of education and research in the health sciences throughout the U.S.

To the existing programs of fellowships in support of thesis research by Ph.D. and M.D. candidates, faculty research grants to members of the M.I.T. faculty, and grants to Harvard faculty who are collaborating in M.I.T. research, the Fund now will sponsor cooperative research by Boston University faculty with their M.I.T. counterparts.

Grants from the Fund are now running at the rate of more than $700,000 annually, according to Irwin W. Sizer, its President.

of our classmates could not have attended.

We have lost **H. D. MacDonald** of Montclair, N.J. He had been President of MacDonald Sales and Engineering for many years. Surviving are his wife Helen, a son Hugh, Jr. and three grandchildren.

We also express sympathy to the family of **James E. Murley, Jr.** of Newton Centre who was a pioneer of radio broadcasting and one of the first staff members of WBZ radio. He was executive producer of the Marjorie Mills Hour, The Yankee Kitchen, and The Marion Winters Show. He was President of the Hytrous Sales, Inc. of Boston. He leaves two sons, a daughter and three grandchildren.

Our sympathy goes to the families of Rear Admiral **Milton O. Carlson** of Little Compton, R.I., **Dean K. Worcester** of New York, **Geoffrey B. Gilbert** of Victoria B.C., Canada, **John B. Wright** of Boston Post Road and **Mrs. H. Langdon Haltermann** of Newport, R.I.

We hope to see you all this summer and fall. — **Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

23

Through Mary Hillis of the Alumni Office we received the greatest piece of news yet. For some obscure reason your secretary had a note on **Pei Y. Chan**'s file card reading "deceased." How this came about he knows not. We are now glad to tell you that Chan is well and active as Chief Engineer of Chukiang Paper Mill of Canton, China. The note from D.Y. Chan of the same enterprise in Canton tells us "Please give my best compliments to our fellow alumni." We have immediately restored Chan's card to our active file and wish him the best of health and continued success!

The account of our 55th Reunion will appear in the next issue and should be about the last time you hear from your secretary (and treasurer) who will by that time have completed ten years of service to the class of 1923. He has found the job a rewarding experience, the high point so far having been the 50th Reunion which was a most active affair actually extending over a period of several months before the occasion.

Now for the not so pleasant news: we have just learned of the death of **Charles W. Cristal** of Shaker Heights, Ohio, on November 25, 1976. Charles was born in Bowling Green, Ky. After graduating from the U.S. Naval Academy, he entered M.I.T. in our senior year and received his degree with us in general engineering. He became involved in electrical construction with the W.W. Clark Corp. of Cleveland, Ohio, where he served successively as Vice President, President, and Chairman of the Board. He was active as an Honorary Secretary of M.I.T. and in various clubs and community affairs.

A telephone call from Royal Sterling told me of the sudden death of **Arthur W. Davenport** who so ably produced the class history. Several of us were so shocked that we groped for a few days trying to think of some suitable tribute and memorial. Because of what Dave did for us and our class it seemed most desirable to do something out of the ordinary.

At the moment when these notes are due we decided to publish here the following thoughts prepared by **Pete Pennypacker** —

With the passing of Arthur Winthrop Davenport on March 24, 1978, M.I.T. lost one of its most devoted and loved members. In 1969 Dave offered to produce one of the first class histories published by Alumni classes and accordingly was appointed Managing Editor. The outstanding book which was published in time for our 50th Reunion proved to be a unique and all-inclusive record of the interests, accomplishments and activities of our classmates. It was done with the wholehearted encouragement as well as secretarial assistance and knowledgeable editorial help from his wife Phyllis, a lady of considerable experience along these lines. In producing this book Dave has not only built a monument to our class but has furthermore left us with a permanently delightful memory of himself. As we read it we sensed his strong affection for M.I.T., his pleasant humor, and his masterful leadership in accomplishing a difficult task that had little support in the early stages. Dave, more than any other person, has drawn us all closer together. Our gratitude to him can only be expressed by means other than words can tell!

"The question was invariably raised by one of our group with an inquisitive mind, 'Why are we here?' and the sagacious reply of their counselor, a renowned scientist of entomology and human behavior, was 'To be a successful human being you should strive to leave the world a little bit better than when you came into it.' This is what the Class of 1923 achieved." — A.W. Davenport (from A Great History of the Great Class of 1923*)*

We have a most belated communication regarding the death of Professor **Randall W. Ludt** of Lansing, Mich. in 1968. Randall received his B.S. degree at the University of Detroit and his M.S. in Chemical Engineering Practice later at the Institute. He was Professor of Chemistry at Marquette University, Milwaukee, Wis., and later at the Michigan State University of East Lansing, Mich. He returned in 1965 when he became Emeritus Professor in Chemical Engineering at that institution.

Frederick J. Ranlett of Redondo Beach, Calif., died on January 29, 1976. Frederick attended courses at the Institute and was a member of Alpha Tau Omega fraternity. After leaving the Institute he became associated with the American Mutual Liability Insurance Co. as a safety engineer. Later he was superintendent of the Fresno Ice Arena in Fresno, Calif., and superintendent of Michael Kirby Ice Skating School, Chicago, Ill.

Finally, we have news of the passing of **John A. Robbins** of Haverford, Penn., during 1977. John graduated with a degree of B.S. in Architecture. After a year with the Electric Bond and Share Corp. he spent his career as President of John A. Robbins Co., Inc., general contractors, in Philadelphia, specializing in commercial and industrial construction. — **Thomas E. Rounds**, Secretary-Treasurer, 990A Heritage Village, Southbury, Conn. 06488

24

The sad news is the death of **Charles H. Wardwell**, on December 21, 1977, at his home in South Dartmouth, Mass. "Hunt" was a fraternity brother of your secretary, a good card player, very soft-spoken, and never one to say much. He did not

bother to wait for his degree in mechanical engineering, but went with Continental Screw Co., New Bedford, Mass., eventually becoming Chariman of the Board and Chief Executive Officer. My lasting remembrance of him was of a luncheon at his Club in New Bedford on September 21, 1938. As we left the main door, I looked at a mercury barometer which read 28.6 inches. Hunt remarked, "That is an old-timer, and probably broken!" Two hours later I was headed for Providence in the Hurricane of 1938 which took 600 lives in New England. Old-timers cannot be wrong!

Paul G. Blampied now lives at 1810 New Palm Way, Boynton Beach, Fla. 33435. He writes an apologetic letter, composed on his return from the Mexican Fiesta, accompanied by a lengthy letter written a month previously which was never mailed. He and **Nish Cornish** were the only 1924 representatives, but survived the 7,000 foot altitude. After the tides and sea ice ruined his Squantum, Mass., shore home, he took a condominium on the Florida shore, where the wind over the water warms him in winter and cools him in summer. He is watching condo prices far outrun the inflation rate.

Ed Moll and **Frank Shaw** continue to look into possibilities for our 55th next year. They need suggestions from the field. The Salem possibility bombed out when Ed inspected possible living quarters amidst the sons of witches. Rockport was badly damaged in the Blizzard of '78.

Your Secretary was under the impression that there would be an occasional up-date of the names for the chairs in new Huntington Hall. As we know of none yet, it should be recorded that **Phil Blanchard** not only subscribed to one, but has also added two for his brothers, Carleton W., '18 and George K. Other generous '24 subscribers to reserve chairs are **Ed Hanley** and **Frank Manley**. There is still room for names on the plaque outside the 10-250 entrance.

Your friendly beavers in the Boston area, led by 55th Chairman **Ed Moll**, have been flapping their tails and gnawing away at possible locations for our get-together next year. Salem, Rockport, and Gloucester, Mass., and Exeter, N.H., have been under surveillance, a year's reservation being necessary for desirable quarters.

Jac Lehman writes from Shaker Heights, Ohio, that he returned in April after five months in Tucson, Ariz. Doesn't say why, or what he did there, but has high hopes of seeing everyone at the 55th. . . . A local paper, on April 16, topped one page with, "In case you didn't know, **Jimmy Doolittle** is alive and well at 81." Of course, he is the fabled flyer who led America's first air strike against Japan 36 years ago. (He looks fit enough to go back on active duty.) Jimmy now has regular office hours as an insurance consultant. . . . Bill LaLonde, '23, was kind enough to send the April issue of *The Brooklyn Engineer* in which was a quarter page titled "**William H. Correale** Helped Write New York City's Building Code." Bill passed away February 22, 1978 in New York City. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart**, co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

25

John M. Campbell, was recently elected a Fellow of the Society of Automotive Engineers (S.A.E.). He is former Scientific Director of the Research Laboratories at General Motors Corp.

John was cited fostanding contributions in the late 1920s toward a better understanding of the relationship between the molecular structure and knocking characteristics of automotive fuel hydrocarbons. Related research led to the tailoring of high octane motor fuels (enabling automobile engine compression ratios to be increased greatly) and a means of standardizing gasoline ratings by octane number. He later discovered the effectiveness of organic phosphorus additives in controlling engine pre-ignition and in the 1950s pioneered fundamental investigations of the then little understood atmospheric photochemical reactions that produce smog.

Established by the Society last year, the Fellow grade of membership was developed to provide a means to recognize the outstanding engineering accomplishments of members. The Fellow grade is awarded to only a limited number each year. John is one of the class of 19 Fellows elected this year. Although S.A.E. has had numerous programs to recognize the engineers for their contributions to the Society, it did not have a means to single out and recognize members for exceptional personal contributions to the advancement of automotive technology — the technology of all self-propelled machinery. Election to Fellow is based on a candidate's notable achievements and personal contributions toward significant or innovative discoveries, products, services, processes, and systems. Only those who have been voting members for at least ten years are eligible for consideration. Candidates must be nominated by another voting member and the nomination must be supported by five references.

It has been a long time since word has reached us from **Anthony Tsongas** and his recent note is much appreciated. Last September he and his wife flew to Greece and spent a month traveling throughout that beautiful country by car, bus, rail and boat. They visited the famous Delphi on Mt. Parnassus, the port city of Volos and its picturesque Mt. Pelion, Thessaloniki of Alexander the Great, Cape Sounion, the Acropolis, a few of the delightful islands and many museums. He says food and wine were very good and reasonable and feels Greece is the best buy in Europe.

Ed Harris reports that he is off on a windjammer cruise around the world through the South Pacific islands: Pitcairn, Easter, Fiji, Bali, etc., getting off at Singapore for a while. If he has any money left he plans to spend some time in his favorite cities: Bangkok, Hong Kong and Taipei. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

Since we devoted last month's entire notes to the disaster that hit Pigeon Cove on February 7, I will simply give a progress report this month. Many classmates have written for more details. Briefly, the house did not fall into the sea because it is on ledge, but as soon as the front came out of the ground the whole wall, front lawn and rosebushes fell. We had expected to build another wall of reinforced concrete closer to the house and on higher ledge, but we could not find ledge. So, we have now decided to get a crane and rebuild the wall of stone, this time interlocking the stones with a wide base of enormous stones and building a slope (batter) into the wall in step fashion. I am retaining a retired stone contractor to supervise the work because a 700-foot wall he built in nearby Manchester is one of the few that survived the storm.

We have a new member of the family at Pigeon Cove — an 8-month-old Shetland Sheepdog (Sheltie). While he doesn't replace Heather he's quite a pooch — the smartest and easiest to train in over 50 years of dog ownership.

Let's get to the news. **John Wills** recently advised that **Bill Davidson** had been ill, so we wrote to him and here are excerpts from his reply. "I was dismayed to see the damage done to our '26 headquarters at Pigeon Cove. We have had a somewhat lively winter, first a heart attack (not too serious) and then pneumonia (quite serious). I saw John Wills twice within the last month. **Chet Buckley** has been getting all Class of 1926 people together. We also saw **Elton Staples** and his new bride and **Jim Offutt** and his wife. They both seemed to be enjoying life. I'd love to hear more of the details of the February 7 storm. Did your boat survive? We have moved from Midnight Pass to 607 Owl Way (Sarasota, Fla.), since we needed a larger place." To answer Bill, the boat was safe under cover, and its buoy is still floating, much to our surprise.

A letter from **John Wills** tells us: "Ellen and I thoroughly enjoyed the 50th Reunion and are grateful to those who planned it so well. We are looking forward to the 55th. We are now in the midst of our annual sojourn in Florida. From my desk I see the widest part of Boca Ciego Bay, the Gulf of Mexico, and the arching Sunshine Skyway Bridge. I am sorry to miss the detailed planning for another one-day conference that the M.I.T. Club of Chicago is putting on in May but am pleased to be serving another stint on the board of directors of the Club."

Elton Staples confirms from Orlando what we reported in January: "I'm getting married in Wellesley on January 21 to Mrs. Helene Perry of Chatham, so will still be in Massachusetts summers and Florida in winter, with trips now and then." Congratulations of the class to Elton. . . . Now here's one for the book! When have we heard from **Clifton McFarland**? I don't recall and this is short but sweet: "Retired from the Washington office of Tippetts-Abbett-McCarthy-Stratton on June 30, 1977." And even my two-thirds namesake **George Warren Bates** has come out of the woodwork: "Retired from teaching, since 1964. Retirement: musical activities; church organist; living in Newburyport."

A clipping tells of the death of **John W. Sanborn** at Bearsport, N.Y., after a short illness. Before retiring John was an electrical engineer with R.C.A. Corp. . . . A letter arrived today from Dorothy Freeman telling of the death of her husband **Raymond A. Freeman** on February 10. Ray died at home of cancer. Dorothy emphasizes how glad she is that they both were able to attend our 50th Reunion. To the families of these classmates we extend the warm sympathy of the class of '26. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

27

For those of you who missed the *New York Times Magazine* of April 9, let me quote a short paragraph on **Hank Steinbrenner**, from an article on his famous son George: "The old man was rigid. Dinner was at 5:45 each evening, and it was 'Please, sir,' and 'Thank you, sir,' and 'May I be excused, sir?' He was an intercollegiate hurdles champion, and he had the kid running hurdles at age 12. If the kid ran three races and won two and finished second in the third, the old man wasn't completely satisfied; he'd come down from the stands asking, 'What the hell happened? How'd you let that guy beat you?' The old man thrived on work. He told the kid, 'Always work as hard as, or harder than, anyone who works for you.' "

Somehow, I never thought of Hank as a martinet. When Marion met him at the Reunion last year, her word for him was "sweet."

Paul Parker and **Fred Willcutt** have filled in a few more names of the unidentified members of the Class in the Reunion picture. If you have a copy of the picture, we'd all appreciate it if you'd scan it and seen if you can add any names. Are you in the picture? Are you correctly identified?

I have an unhappy total of seven deaths to report this month.

Jacob C. Muskin died in 1977; I do not have the date. As late as the spring of last year, he had written that he hoped to be at the Reunion. He had recently retired as a partner in Singmaster and Breyer, New York City metallurgical and chemical process engineers, Jack had originally joined the firm in 1942. He was a member of the A.S.T.M. and A.C.I. He leaves his wife, Fanya, a son, and a daughter.

Malcolm McNeil, '26, wrote to me in mid-March to tell me of the death of his brother, **Gordon I. McNeil**, who was vacationing in Florida at the time. I have expressed to his wife, Eleanor, not only the sympathy of the class, but my own personal grief. Gordon, Malcolm, and I were at high school together and were good friends until our paths diverged after graduation. From graduation until World War II he worked for Goodyear, in Akron, specializing in the development and sale of mechanical beltings to General Motors, Chrysler, and other automotive companies, and conveyor belts to the cement, sand, and gravel industry. With the war, he became involved in the development and sale of caterpillar tracks for tanks and other military vehicles. When the war

ended, he became engineering sales manager for Standard Products in Port Clinton, Ohio, where he continued in the development and sale of caterpillar tracks, most recently for snowmobiles. He retired in 1976. He was a past commodore of the Port Clinton Yacht Club and an active Mason. Besides his wife, he leaves two sons, William B. and Malcolm. His brother Malcom sums it up in one sentence: "He was a great guy, and had a tremendous concern for others."

Benedict Hirshon passed away on March 7. He had interrupted his career as a pharmacist to become a welder at Fore River during World War II, and then to operate a landscaping company for a dozen years. He returned to pharmacy in 1959 and retired in 1975. Survivors are his wife, Frances, three daughters, and a son.

Charles G. Kloer of Circle Pines, Minn., died on September 13, 1977. **John F. Burke** of Wollaston, Mass., died January 20, 1978. Both received their degrees in architecture. I have no recent information on either.

Winthrop M. Puffer, also an architect, passed away on February 27, 1978. Before his retirement in June, 1964, he was in charge of specifications at Charles T. Mains, Inc., consulting engineers. He was a past president of the Boston chapter of the Specifications Institute and a charter member, as well as a National Director, of the Construction Specifications Institute. Since his retirement, he and his wife, Alice, had been living in Gulfport, Fla.

Frederick A. Bodden died on March 17. He had retired in 1966 as a sales engineer for Mirro Aluminum Corporation of N.Y. and had been living in Short Hills, N.J. He was a member of the Old Guard of Millburn, N.J. He is survived by his wife, Helen, two daughters, a son, and ten grandchildren.

Finally, one brief note to break the melancholy list of obituaries. **Russ Westerhoff** writes that he has become a ham radio bug and, in order to upgrade his license, has been studying amateur radio theory and practicing code for several months. (He did not include his call letters). He and Kitty are planning a trip to Spain toward the end of June. — **Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N.Y. 10583

28

It is mid-April as these notes are being written. Each daily mail brings in a new batch of registrations for the big 50th anniversary gathering of M.I.T. '28 on campus. The level of enthusiasm is evident in the fact that in the first week alone registrations came from well over half of those who said they would attend. When you are reading these notes the 50th Reunion will be a matter of history. Right now, however, everything indicates that it will be a great and happy occasion.

Several classmates have written to say they have memorabilia from undergraduate days to exhibit in June. **Harlan Paige** has promised to bring a photo album of 1927 ROTC Camp snapshots taken at Langley Field. . . . **Ernie Knight** has a copy of the Class Picnic group picture taken on one of the Boston Harbor Islands. He also has a bottle of beer saved from a class party in freshman days and several copies of the Filter Paper. The latter, you may recall was a humorous scandal sheet with the motto: "Catches all the dirt." . . . Earlier we had a note from **Dempe Dempewolff** saying that he would bring along his keepsakes of student days. It is our hope that enough others will bring similar items to provide a diversified though perhaps nostalgic exhibit for our meeting at the M.I.T. Historical Collections.

Denny Ver Planck, in a letter to **Jim Donovan**, reports that he has just had heart by-pass surgery and will not be able to attend the reunion. He *is* hoping for the 60th! Denny also described his delightful experience of an unexpected meeting with **Arthur Elliott** this spring while each was out walking on the beach. As students they did their master's theses together and had not seen each other therefater for 49 years. This gave rise to a mini-reunion of several days duration which, of course, included the ladies. . . . **Bob Carder** will be traveling abroad during the first two weeks in June so he will not be with us in Cambridge. . . . Others of our classmates who have had to forego the trip to Tech because of health problems include: **John Carvalho**, **Gerry Brickett**, **Martin Bardwell**, **Charles Newhall** and **Wally Bissell**. To each of these gentlemen we send our sincere good wishes.

We have had further correspondence from several of our class widows. Ethel (Mrs. **Carl J.) Bernhardt** says she will have to give up her conflicting social activities but has every intention of attending the 50th. . . . Frances (Mrs. **Carl F.) Myers** had already arranged to be in Amsterdam, Netherlands for a 45-day visit with her son and his family. Otherwise she would have enjoyed being with the class in June at M.I.T. . . . Ruth (Mrs. **Robert N.) Tucker** sent her regrets but with her good wishes and a blessing for those attending. . . . Mary (Mrs. **Arthur A.) Nichols** not only plans to attend but is an active member of the reunion committee. For those who may be wondering about it, the 50 Year Class Book is well along in its preparation. Copies will be mailed to those who returned a completed biographical sketch form. Classmates attending the reunion will receive their copies at that time.

We are very sorry to report at this time three classmate deaths. **Edward W. Roessler** died on December 30, 1977. His wife, Susan, told us that his death was unexpected. Edward graduated summa cum laude from Dartmouth College in 1925. He then studied at M.I.T. and received his S.M. degree in 1928. His whole professional life was with General Electric Co., first at Schenectady, N.Y., then at the Bloomfield, N.J., plant. His specialty was in the design of air conditioning equipment and systems. At one time he was mayor of his township and served in many other community benefit activities.

Harold W. Northcutt died on December 13, 1977. Harold graduated from the U.S. Naval Academy before entering M.I.T. for graduate work. His wife, Marie, told us that his high academic standing at the Academy earned him the nickname of "Savvy."In 1930 he resigned from Navy service to work for Bethlehem Shipbuilding Corp. in Quincy, Mass. In 1938 he transferred to the company's Staten Island yard. The importance of his work during the war period prevented his return to the Navy. He was awarded a Certificate of Commendation by the Chief of Bureau of Ships for his contributions. Besides Marie, Harold leaves two sons.

Christopher M. Case died on April 19, 1978. His wife, Ruth, told us that although Chris had not been well his death was not expected and they had been planning to attend the reunion in June. Ruth very thoughtfully sent us a newspaper clipping giving details of Chris' life. He was born in Willimantic, Conn., always lived there and was a lifetime dedicated and respected participant in city politics and many other community service activities. Chris' professional career was with Veeder Root, Inc., in Hartford, Conn., where he worked as an industrial engineer. To all three families we extend our deepest sympathy. — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, Mass. 01890

29

The "Count Down" is really on now! Exactly, one year from now, we will be celebrating our 50th Reunion and you'd better plan to join us! You will not have a second chance. Chatham Bars Inn (the Cape) has been reserved for the event.

A note from **Neal Wells** reads in part, "On February 25, we attended a golden wedding anniversary reception at the MacDill A.F.B. in Tampa, Fla., for **Sydney C. Hardwick** and his wife Frances. Relatives and friends down to the fourth generation participated. Among those present were **Stephen N. Dilworth** and wife Myn, and Roman Ortynsky, '36. We reminisced about our 40th Reunion at Wiano with the Dilworths, and you can count us in for the 50th Reunion in 1979." . . . **Jackson H. Emery** writes, "Thank you for the birthday greetings. Since my wife died in 1975, I decided to move to Pennsylvania to be nearer to my daughters. I now live in Morristown near one daughter and only 45 minutes ride from the other daughter. I moved here in April, 1977 and have been busy doing volunteer work on the New Hope and Ivyland R.R. It is a steam road, operating weekends, from April through November. Road #9 was originally built for the U.S. Army, and later saw service on the Virginia Blue Ridge Railway prior to entering excursion service. I also work for 'Meals on Wheels' one day a week in West Norriton township."

William F. Jenkins has sent a note: "The most satisfying thing that I have done lately is to set to music Robert Browning's verse which starts, 'Grow old along with me, the best is yet to be . . .' This is the first time I have ever written the chords as well as the tune for a song. So, I have opened up a new avenue for mental travel. Most of my time is taken up with helping my wife doing gardening, landscaping and planting trees in my arboretum. We have a 'hayride' scheduled for next month, and I am considering putting in a pond on my land, so the state can stock it with fish for me."

Sam Shaffer and his wife Sybil who attended our 40th Reunion has sent a note, "Thanks for the great job you are doing as Secretary. Our class has more news than most of the others. My wife and I are enjoying good health and I keep busy doing financial consulting work for corporations and personal projects. I also manage investments and am consultant to insurance companies on direct marketing. I serve on two major committees of the 'United Way,' and am a member of the Finance Committee of the Jewish Welfare Federation. I dabble at golf three times a week and try to keep a good garden for health and shape."

Roger A. Sykes writes, "We have both managed to pass the 70-year milestone, spending winters in Florida and summers in New Hampshire and enjoying both. Once a month, we meet friends at a meeting with career or hobby interests. Have followed with some interest the gradual transition from analogue to digital techniques, through the solid state art. For a youngster starting out at M.I.T., it looks like a mighty interesting future. It might be fun to start our careers in this field all over again!!"

James C. Reddig has sent a note stating that, "I have just returned from a three-day conference on Advanced Technology Airfoil Research at N.A.S.A.-Langley Research Center (Hampton, Va.). The dinner meeting was addressed by **Ira H. Abbott**. I enjoyed the warm hospitality of **Paul S. Baker** and his wife Kay, at Williamsburg, nearby. Paul also attended the conference. A whole new 'basket' of airfoil shapes has opened up and computerized means of developing new ones. Returning home, I stopped in Schenectady for a couple of days to see and visit 'Bomber Bill' Col. William D. Harrison, '31, who was with the Aero gang through our 1925-1929 stint at M.I.T. The Colonel had just returned home from a minor surgery."

A note from professor **Herman P. Meissner** announces the death of **Ed Powley** on March 30, 1978. Ed, whose wife passed away a few years ago, was a loyal alumni who attended most of our reunions and supported all our class functions. He will be missed by all who knew him. Before his retirement, he was an executive of Cities Service Oil Co.

I regret to announce the death of two more of our classmates, **George J. Burke** of Swampscott, Mass., on January 25, 1978; and **Winfield H. Bearce**, Naples, Fla., on March 5, 1978. George was the president and treasurer of a family-oriented contracting firm. He had a distinguished professional and political career. He was the chief engineer in charge of the construction of the Sumner Tunnel in Boston, Sudbury Tunnel in Natick, the Fort Holabird Tunnel (Maryland) and the office tunnel for the U.S. House of Representatives in Washington, D.C. He worked for the federal government for ten years after graduation and was in charge of the construction of many buildings for the Navy. When the war ended George went to the Dominican Republic as a general superintendent of a $52 million project,

involving the construction of roads, dams, pumping stations, sewer drainage lines, and others. He was active in Swampscott politics. He was a member of the Board of Public Works for 15 years, being chairman of it for 13 years. He is survived by two sons, George J. Burke, Jr. and John F. Burke.

Winfield Bearce was an electrical engineer at the Central Maine Power Co. for 35 years, in charge of distribution at the time of his retirement. He was active in South Parish Congregational Church of Augusta (Maine) for many years, being a former Trustee and Deacon. He was a member of the Society of Mayflower Descendants. He was living in Naples, Fla., at the time of his death and is survived by his wife Marguerite (Murlless) Bearce and a son Winfield H. Bearce, Jr. — **Karnig S. Dinjian**, Secretary, 10 Ancient Hwy., Plaice Cove, Hampton, N.H. 03842

30

This month we have a rather full report from **Phil Holt** who has now been retired for about seven years. Phil's first job after graduation was with Goodyear in Akron for whom he worked for about five and a half years. He then switched to Esso Research and Engineering Co. During his approximately 35 years with Esso he worked on research and development and research administration, which required lots of travel to Europe and occasional Mid-Eastern trips to points as far away as Baghdad. During the latter part of his career he worked in general administration, including jobs as chairman of the company bargaining committee for union negotiations and manager of executive development. At one time he was active in fund raising for United Way and Red Cross, and he served six years as Trustee of the local hospital. However, he is no longer active in any of these areas. Phil has been developing his artistic talents. For a number of years he has been painting in oils, watercolor and pastel, and more recently he has been studying piano. He says he hears occasionally from **Jack Bennett**, **Ted Riehl** and **Herm Botzow** but has not seen any of them in about two years.

Dwight Horton, Jr. is still living in New Braunfels, Tex., where he is Comal County Engineer and also does some private consulting work. . . . As previously reported in the Notes, **Frank Hankins** ran into a problem with Parkinsonism about ten years ago. Prior to that he pursued an active career including 15 years at Pan American World Airways as a pilot and 15 years with Curtiss Wright as an executive engineer and later the Service Vice President. After that he worked for five years for Lockheed Air Service, retiring in 1967. He also served as Mayor and Councilman of Franklin Lakes, N.J., where he still owns a home. The Hankins plan to sell their home in Franklin Lakes and make Fort Pierce, Fla., their permanent address. Frank says that thanks to Eldopa and its derivative Sinemet his Parkinsonism is under pretty good control.

Tull Houston has largely retired from his industrial and commercial real estate brokerage business in favor of his son David, Jr. He made himself Chairman of the Board and Dave, Jr., President of the company. The Houstons home base is Short Hills, N.J., but they have bought a lot in Hilton Head Plantation, S.C., where they plan to build a second home. Tull and his wife do considerable traveling, including a trip to his native Scotland last September for two weeks and two weeks in Bavaria and the Austrian Tyrol. More recently he spent two weeks at the Buccaneer in St. Croix, thereby missing a lot of snow. Tull says that he has recently seen **Jack Osborne**, who is active as a consultant to M.W. Kellogg Co. and lives in Chatham, N.J.; **Bob Reynolds**, who has retired to Cape Cod; and **Herm Botzow**, who is still farming in Ohio. . . . **Ed Hawkins** is now semi-retired but does occasional consulting work relating to utility management. He and his wife live in Petersburg, Va.

Maurice "Yicka" Herbert is still operating the Franklin Paint Co. of Franklin, Mass., of which he is President and sole owner. The Herberts take a vacation in Switzerland each spring and vacation in the summer at a lakeside summer cottage at Stinson Lake, N.H. Yicka collects ancient gold coins, mostly prior to 300 A.D. and characterizes his collection as "a terrific investment." . . . A note from Hermon Swartz, '28, brings the news that our classmate **Arthur Senior** died of a heart illness on September 6, 1977. Arthur prepared for M.I.T. at Newton High School and at Chauncy Hall before entering M.I.T. with the Class of 1928. He took Course I and after graduation spent a year or so with the Brooklyn Gas Co. before joining the Massachusetts Department of Public Works as a field engineer. He worked in the latter job for more than 30 years and retired six or seven years ago. He lived in Newtonville most of his life and never married. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

A note from **Cato D. Glover** says that on April 13, 1976, he married Jewett R. Spencer, widow of Richard P. Spencer, Jr. of Columbus, Ga. They divide their time between Cato's home in Camden and Jewett's lovely home in Columbus. They have traveled all over the world. Cato reports their life is a "great one." I hope that Cato's marriage is as happy as mine was until Sally died on March 3, 1978. . . . **Tom Pureka** reports that the M.I.T. Club of Cape Cod has become very active since it was organized quite recently. He reports that a surprising number of alumni have retired on the Cape. Tom's address is 19 Old Oyster Rd., P.O. Box 203, Cotuit, Mass. 02635. . . . Congratulations to **Jack Gordon**'s widow, Helena, who has been named by the Jewish Theological Seminary of America to receive its prestigious National Community Leadership award. Mrs. Gordon is being cited "for exemplary leadership in all endeavors to enrich the life of the community and for selfless support of the programs of the Jewish Theological Seminary of America."

A clipping from our prexy, **Howie Richardson**, tells that the Martin Marietta Corporation Foundation has endowed a professorship at M.I.T. in honor of **George M. Bunker**, former Chairman of the Board of the Corporation. The chair will be known as the George Maverick Bunker Professorship of Management in M.I.T.'s Alfred P. Sloan School of Management. . . . A letter from **Gerald Benoit** to **John Swanton** reports that on February 23, 1978, **Roger Brown** of 5749 Mira Grande Dr., El Paso, Texas 79912, passed away following a heart seizure at home after playing golf in the morning. He was President of Roger P. Brown Co. for many years and a veteran of World War II. He leaves his wife, Caroline, and five children. Our sympathy to his family.

Wyman Boynton sent John Swanton a clipping telling of **Kendall Clark, Sr.**'s death. Kendall was an advisory engineer with the Systems Product Division of I.B.M., Poughkeepsie. He retired in 1974 and had been a consultant and gunsmith. In 1935, while associated with Bendix Aviation Corporation, he took the inventor's model of the original Bendix Home Laundry and reduced it to a production model. He joined the Frigidaire Division of General Motors to design the Frigidaire automatic washing machine. At the same time he set up his own business, New Products Manufacturing Company, Inc. Under prime contract to the Air Force, he developed and produced the reflex attachment for the Norden Bombsight, and other electronic and optical equipment. At the time of his death, 77 patents had been issued to him and several are still pending. In addition to his wife, the former Edith Colson, he is survived by two sons, a daughter, two sisters, eight grandchildren and eight nieces and nephews.

A newspaper clipping also reports the death of **Walter Gompertz**. Our sincere sympathy to all of their families. — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, Fla. 32757; **Ben W. Steverman**, Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, Mass. 02158

32

I recently had the pleasure of talking to **Donald Brookfield**. He is no longer President of Brookfield Engineering Laboratories but is Chairman of the Board. His main interest is in the development of new products. The company recently started a research laboratory in Florida and perhaps some time in the future he will spend more time in Florida. Phyllis and Don lost their oldest son, who was in the Air Force, in 1964. They have an unmarried son who is active in their company. Incidentally, he is a seeded tennis player. The other four sons and daughters are married and spread over the country — Colorado, Oregon and Washington, D.C. The Brookfields have four grandchildren. Visiting the family keep Don and Phyllis on the move. Don also keeps active with tennis, golf, and M.I.T. activities and friendships whenever and wherever he can.

I had the opportunity to spend some time with Kay and **Bob Minot** recently, and I told Bob it was about time we heard about his activities since 1932. He agreed and here follows his story.

"In 1932 there were no architectural jobs available so I sold architectural supplies. In this way I kept in touch with architects' offices. After a while I found part-time work and eventually full-time work with Royal Barrey Wills, Architect, '17.

"In the next 44 years I collaborated with the firm in designing about 3,000 homes throughout the United States, England and the Virgin Islands. Perhaps the highlight of my career was getting our company the design for the new Supreme Court Building in Concord, N.H. The Governor was looking for a traditional style of architecture, much to the dismay of younger contemporary architects.

"I've been a member for seven years of the Beacon Hill Historic Commission appointed by the Mayor. I've been an officer for many years of the Boston Society of Architects. I was a co-author of a book entitled, *More Houses for Good Living.*

"Since 1976 I have been semi-retired and act as a consultant to my firm. Presently I'm working with several young couples who are building new homes in Texas. Unexpectedly, they are looking for New England style architecture for Texas.

"Kay and I are avid antique collectors. We are also members of the Waltz Group in Boston. Waltzing is currently enjoying a strong revival. Kay and I were married in Chicago in 1940. We have one married daughter and two very active grandchildren. We have an antique summer home in Nantucket."

Thanks Bob. The Minots look well and hearty.

Mrs. Dwight B. M. Scott became Professor Emeritus of Biochemistry in 1977. The Scotts have moved into a new home around the corner and are still in the center of Philadelphia. . . . The alumni office has belatedly received notice that **James E. Paige** died on January 5, 1969. — **Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, Mass. 01907

33

For the first time in all these years **Walt Skees** appears in the U.S. — banner headline! During Easter he visited his 15-year-old son from a third marriage.

According to Walt, the cost of living in Barcelona for an eight-room apartment is about 30,000 U.S. dollars. All education in Spain from the first to the university level is free to all natives and foreigners. Walt thinks this is a suitable inducement. He included a sketch of his eight-room apartment, and admittedly he has something there. Yet I have been in Barcelona myself and don't see it the same way. To me, there is nothing like Florida.

Cal Mohr and **Bill Pleasants** recently exchanged letters of reminiscence, and they were hilarious in spots. They spent some time (it must have been during World War II) discussing how they shipped goods through Nova Scotia to avoid U.S. dock strikes. Cal is retired, but Bill retired and then started over. He has a job with E.P.A.

Water Quality Management. . . . I have exchanged many letters with **Ellis Littmann**. Inasmuch as he is heir to the throne, he has the right to say who his officers will be.

From **Bill Huston** we have a fine post card with a photo of Chidambaram Temple. . . . **Mal Mayer** sends a card from London showing the Westminister Bridge and surrounding scenery. He tells me that he saw my son on T.V. in Florida, and also that he searched all over Egypt for **Niazi Mostafa**. Misty intends to be at the 45th Reunion.

Early in March I wrote to **George Stoll** asking him for some information regarding our reunion. It appears that all alumni mail for the reunions goes out second class or worse and is never forwarded. As a result, I have had no mail since the first part of the year.

George responded with one of the nicest letters I have ever received, deserving more space than I can give it. He and Jane seem to be very busy in all but the spectator's court, and Jane is greatly interested in the Camp Fire Girls. George describes an unusual experience last summer: "A couple, who have been our 'boating cousins' chartered a 35-foot power cruiser and we spent two weeks on the River Shannon, amongst castle ruins, cows, and beautiful cruising waters. Numerous pubs and their lovable patrons and patronesses abound in numbers even in the smallest of villages. While in the vicinity, we flew to England where we spent a week doing a circle by car, including the Cotswolds, Baths and back to London."

Around March 1, I had a double eye operation on the same eye. I spent only five days in the hospital and the remainder of the time at home. Until I get the use of my left eye, my efficiency will be impaired.

I have another card from **Bill Huston**, sent from India, where he is acting as a consultant on their communications and weather satellite program. Bill got a chance to ride an elephant at a speed of 1.5 mph. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Drawer H, Exeter, N.H. 03833

34

Most of this month is culled from Alumni Fund notes — some from rather familiar names. **Russell Hastings, Jr.**, writes, "Although age 65 brought on compulsory retirement (from Clark Equipment Co., Industrial Truck Div.), I am continuing to work on American National Standards, American National Metric Council, and other work in engineering consulting." . . . That reformed Floridian, **Phil Kron** says, "I am now an Adjunct Professor of Purchasing at Rochester Institute of Technology teaching a four-credit-hour course three quarters during the school year. I average 43 students a class, mostly seniors in the College of Business. It's exciting and challenging, plus fun. Ellie and I are enjoying town house living in the Rochester area."

Here are more notes from others who have been relaxing for a while. **Al Schulerud** notes, "Retired May 1, 1974. Doing part-time consulting in my specialty — Saponification Processes. Also keeping busy with golf, bowling, gardening, auto repair, and singing. Traveled by car through Nova Scotia and Gaspe in the early summer this year (1977)." . . . From almost next door **Warren King** writes, "Have been consulting on a part-time basis for the Acushnet Co. Visited England for the month of October — love the Devon Coast of the Bristol Channel [he should see that part — or any other — of England in the spring]. Plan to take our ketch down to Florida and Bahamas again next fall."

William Alexander is another member of the class who had to quit at 65. I can't help wondering how they feel now that the law has been changed just a few months later. He says, "Retired at compulsory limit of 65 from R.C.A. Corp., Moorestown, N.J., after 36 years as Senior Member, Engineering Staff — 450 of the world's best engineers and gentlemen — a great life from start to finish (radar, space, AEGIS, etc.)." . . . **Ed Sieminski** may have an answer to the question I just raised when he notes, "Finally retired from Grumman Aerospace Corp. and find more things to do and less time for doing than ever while I was 'working.' Succeeding in keeping my good health but it is a struggle. Rebuilding some inherited properties in Massachusetts. Visiting with my son's family in California — four bright grandchildren. Felicia and I still recreate by dancing on ice skates. Miss the intensity of the aerospace business but am enjoying my new way of life. Looking forward to the future and not back on the past, paraphrasing Satchell Paige, the baseball player who said it eloquently." . . . A final Alumni Fund note — from **Vic Mooradian**: "Took an early retirement from Englehard Industries, Inc., on January 1, 1977. Doing some consulting work in metallurgy and enjoying retirement."

Adolph Warsher got slightly mixed up with the Class of 1932, but his information has finally landed in the right place. He says he has been associated with Draper Lab's FBM Guidance System Program since he left General Motors in 1973. His son James has returned to M.B.T.A. after three years with Amtrak in Washington. . . . A release from the International Executive Service Corps tells of a one-month assignment **Richard Bell** had with Diatomita Peruana, S.A., in Lima, Peru. He was there to help the company determine the feasibility of operation and subsequently to develop and expand operations in the area of mining. It must have been a nice assignment as he was able to take his wife with him.

The March/April issue of the *Review* carried a brief mention of the A.T.A.'s Engineering and Maintenance Forum Award to **John G. Borger**. John has been with Pan American since 1935 and has worked on at least 32 types of transport aircraft from the Martin flying boats to the Boeing 747 SPs. His award was for "an unrelenting search for better payload-range performance, for greater speed, safety, and economy that has challenged manufacturers to produce aircraft that have made more and more of the world accessible to growing numbers of its people."

The backlog's all cleaned up so I don't know what you'll be reading about next time. Have a good summer and share some of your adventures with us. — **Robert M. Franklin**, Secretary, 620 Satucket Rd. (P.O. Box 1147), Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Chevy Chase, Md. 20015

35

We have a few short notes received through the M.I.T. Alumni Fund Office to fill out this column. From **Joseph S. Oldham**, "Retired. Still an avid sculler." . . . From **Leslie Fitz Gibbon**, "Recently elected treasurer of the U.S. Tennis Association." . . . From **John Taplin**, "Along with a friend, bought the Lehigh Fluid Power Co. in Lambertville, N.J., from **Philip Johnston**, also class of 1935." . . . And from **Lew Simon**, "Retired last August and recommend it highly to all you workaholics. Had slight third heart attack December 14, hence no Christmas cards. Any of you touring West drop in at Camarillo, Calif., (805)484-5240."

Sidney Fox

Bethlehem Steel announced the retirement of **Sidney V. Fox** in February after 42 years service with the corporation. Sidney was senior research engineer for the past two years. He is a member of the American Chemical Society, American Institute of Chemical Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, Hunterdon Art Center, and the Amateur Chamber Music Players, Inc. As an amateur violinist he has played in the Allentown Symphony and other local groups.

Robert Scott

The B.F. Goodrich Chemical Division announced the retirement February 1 of **Robert D. Scott**, its executive vice president in Cleveland after 42 years of service. Bob Scott joined B. F. Goodrich in 1935 as a chemist in Akron, Ohio. In 1940 he was named Technical Superintendent of the Chemical Plant and later that year transferred to Niagara Falls as General Foreman of a new plant. In 1951 he was moved to Cleveland as General Manager of Chemical Division Plants and in 1955 was named vice president-manufacturing. He was appointed executive vice president of manufacturing and development in 1964 and to his present position in 1972.

I was recently in Peter Bent Brigham for kidney stone surgery, but now, all is okay. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

36

Elliott Robinson in his letter asking for contributions to the Alumni Fund cited the highly disproportionate number of class members who had contributed to refurbishing Room 10-250 and offered congratulations. **Bernard Cosman** has given some background for his generosity. He writes, "Very fond memories of 8.01 to 8.04 lectures in 10-250 prompted me to sponsor one of the new chairs. My son Eric is holding up the M.I.T. tradition much better than I. He earned an S.B. in Course XVIII (1963), a Ph.D. in Course VIII (1966), and then joined the M.I.T. academia where he has risen rapidly through the ranks to Professor of Physics. I understand from others that he has been a favorite lecturer for 8.01 since 1968." . . . I have received news (but no further information) of the death of **Harold Carmichael** of Rutland, Vt., last February 14. — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

40

Happiness Is: **John G. Burr** writes, "Have put six of seven children through college and last is halfway through the University of Calnifornia at San Diego. Two of them have Ph.D.s, one has the M.S. and two others are working on that degree. I am still a happy professor of chemistry at the University of Oklahoma, Norman, Okla., still getting grants and publishing papers. Spent sabbatical in 1975-76 in Germany and at Hebrew University of Jerusalem as a Visiting Professor at each place. One of the best things about being a scientist is that lovely travel."

The Hard Stuff! **William P. Lamb** has joined Dravo Corp.'s Minerals and Metals Division as a marketing manager. Dravo is a diversified engineering, construction and manufacturing firm. In his new position, Bill will be responsible for

marketing the division's engineering, construction and project management services, both domestically and internationally. Bill was formerly vice president of business development for Ralph M. Parsons Co.

Global: **I.M. Pei** continues his highly visible activities from Singapore to Bloomingdale, Ind. He mixes his architecture with a generous attitude about people and a wide-ranging life-style described in a recent feature of the Worcester, Mass., *Evening Gazette*, last December 13.

Cool: **Henry Singleton**, Chairman of Teledyne, Inc., continues to fascinate Wall Street buffs and the corporate world. The *Wall Street Journal* (January 16) featured his techniques for managing and expanding the growth of Teledyne.

PR Connection: Angel M. Gonzalez, '43, very kindly writes about **Rafael Martinez**. "Rafael was recently made a member of the Board of Directors of the Bank of Nova Scotia of Toronto, Canada. He is also Chairman of the Board of Banco Mercantil, a Puerto Rican bank and a subsidiary of the Bank of Nova Scotia. He is the first Puerto Rican, and Latin American, elected to this position."

Sad Duty: We must report the death of **Jane L. Hatter** (nee Hastings) in Harwich, Mass.

Reports, Please: If you attended any of the reunion events this year, please send news of our classmates directly to me. — **Frank A. Yett**, Secretary, P.O. Box 562, Long Beach, Wash. 98631

42

Mort Goulder has just been elected Chairman of the Board of Trustees of Rivier College. Mort is the former Deputy Assistant Secretary of Defense for Intelligence and Warning Systems. You will recall that he is a Founder, formerly a Director, Vice President and Corporate Scientist of Sanders Associates. Mort graduated as a physicist from Course VIII and is now operating his own consulting business in Hollis. We congratulate him and wish him the best of success in his new and prestigious position.

Charlie Speas is the General Chairman of the Society of Plastics Engineers Annual Technical Conference (ANTEC) in Washington. Charlie is Technical Vice President of Hedwin Corp. in Baltimore. More important, he is "Mr. M.I.T." of Baltimore and the general Maryland area.

John Fellows writes that "after three retirements I am actively engaged in metallurgical consulting in product liability cases."

Hawk Shaw sent in a most attractive new brochure on **Bob Rines'** Franklin Pierce Law Center which is the unique law school which specializes in law as it affects science and technology. Right now, Bob's school is having growing pains, but according to the brochure has 340 students from 38 states, territories and foreign countries. His flier says that 76 per cent of his students pass the bar examination on their first try. This is certainly an amazing record. We wish Bob continued success in his interesting undertaking.

One obit this month: **John W. Brumbaugh**, a patent attorney in New York City for many years, died on January 9 while skiing near his home in Westfield, N.J. John was not with us as an undergraduate but did graduate work at M.I.T. We extend our condolences to his wife and to his family. — **Ken Rosett**, Secretary; 191 Albemarle Rd., White Plains, N.Y. 10605

44

We are writing these notes in April for the June issue of *Technology Review*. About the time you will be reading these comments, we will be at Technology Day (erstwhile Alumni Day) at M.I.T., June 9. The ceremonies this year will center around the refurbished 10-250, Huntington Hall.

In a *Boston Globe* item, earlier this year, the heritage of Huntington Hall was explained. We paraphrase from that article.

Huntington Hall was named for Ralph Huntington, who also gave his name to Huntington Ave. in Boston. Born in western Massachusetts in 1784, Huntington came to Boston in 1808, transferred his mercantile activities to the West Indies in 1812 and then returned back to Boston in the 1820s. He became interested in the potential of the marshes west of Boston and, joined with the landowners and other promoters, set out the "western road," later to bear his name, across the swamps.

As a director of the Boston Water Power Co., which had power rights on the total flow in the Back Bay, he was responsible for the eventual arrangement with the Commonwealth to fill in the bay, and thereby create what has since been known as Back Bay. The great success of this venture made Huntington rich; much of this wealth he left to M.I.T., hence Huntington Hall.

From **Robert Copsey**, in California, we hear about the Navy's communication satellite. On February 9, while New England was still snowbound from the Feburary 6 super-blizzard, the Navy launched its satellite. Bob is a project officer and engineer in this program. His technical paper on his work on this project won first prize in 1977 from the Professional Association of Naval Electronics Engineers and Scientists.

We heard also from **Al Picardi** in Edmonton, Alberta, Canada. He and Mary moved up there at the beginning of this year. He is now Senior Vice President, for Construction, for the Oxford Development Group, Ltd. The impact of M.I.T. on the Picardi's, and vice versa, continues. Son Tony and daughter-in-law Shirley took their doctorates at M.I.T.; they work in Boston. Son Alfred and his bride are in Boston while he finishes his work at M.I.T. Al's daughter is a physician in the Pickins Clinic at Duke University where her husband is a professor in biophysics. Al and Mary invite classmates to venture and visit; they plan to be at the 35th.

One of our classmates, **Andrew F. Corry**, has been honored by election to membership in the National Academy of Engineering for acheivement in technology and for leadership in research and development.

Nicholas J. Grant, who received his doctorate at M.I.T. in 1944 and is M.I.T.'s ABEX Professor for Advanced Materials in the Department of Materials Science and Engineering, has been appointed by Dr. Frank Press, science adviser to President Carter, to be chairman of the U.S. group of the U.S./U.S.S.R. Working Group for Materials and Electro Metallurgy.

Ralph W. Turner has been named Vice President of Engineering for Southworth, Inc., at Portland, Maine. . . . **Joseph Kauffman** is President of Kauffman Electric Co., in Baltimore, Md., where they rebuild and distribute electric motors and generators for two of the country's major manufactures. . . . **Franklin R. Amthor, Jr.** is now Vice President of Engineering at Energy Utilization Systems, Inc., a company that does product development and consulting towards the conservation and management of energy.

We regret to record here the death of **Arthur S. Karol**, of Weston, Mass., An engineer of note in the structural field, he was active in community, religious and philanthropic organizations and a founder of Technion Institute in Haifa, Israel. — **Melissa** and **Newton Teixeira**, Co-secretaries, 92 Webster Park, West Newton, Mass. 02165

46

Robert (Bob) F. Hoffman has his own consulting firm in New Jersey, specializing in mechanical and industrial engineering. He is currently working with several clients on energy efficiency and conservation. . . . **Peter G. Peterson**, who attended M.I.T. for two years and earned his B.S. at Northwestern, has become the chairman and president of the combined securities firm of Lehman Brothers and Kuhn Loeb and Co. Mr. Peterson began his career at McCann-Erickson, the advertising agency, rising to a vice president at the age of 27. He left to become President of Bell and Howell and then moved to the chairmanship of that concern. In 1971 he was named to President Richard M. Nixon's White House Staff in Washington, later to become active in foreign trade matters. In 1972, he was named Secretary of Commerce. Mr. Peterson left Washington before the Watergate affair began to affect and erode the Nixon Administration and joined Lehman Brothers as Vice Chairman. Two months later he became Chairman with the authority to reorganize the financially troubled Lehman Brothers. The merger with Kuhn Loeb and Co. is the latest accomplishment for Mr. Peterson.

Until next time — **Russell K. Dostal**, Secretary, 18837 Palm Cir., Fairview Park, Ohio 44126

47

Earl Iselin writes that in August last year he was promoted to Associate Professor at the University of Dayton, where he is actively involved in the co-op program. This summer the Iselins will be remodeling their newly acquired cottage on Kaiser Lake. . . . **Joe Dennison** has retired from the product metallurgy section of Bethlehem Steel Corp.'s research department after more than 30 years with Bethlehem. His principal research interest there has been in the development of new and improved steel compositions for plate and linepipe. He is the co-holder of several U.S. patents and has co-authored a number of technical papers dealing with plate steels. Joe's plans include relaxing, enjoying his family, and taking some short trips.

Joe Dennison

Bob Connors has been doing a lot of traveling around the country, mostly in connection with his business. In his position as a vice president of Kurt Salmon Associates, the largest textile manufacturing consulting firm in the world, he is responsible for the knitting and hosiery industry practice part of it. The company covers the complete industry and is worldwide, with projects in Egypt, Iran, Manila, a considerable amount of business in South America, but still with the bulk of their business in the U.S. Bob and Ginny are still in Marietta, Ga., with one of their five children still at home. Leisure interests are swimming, boating, fishing. Our 30th reunion last year was a double-header for Bob: it was also his father's 55th reunion. We look forward to another double-header in 1982.

From steel and stockings we move to the Spanish Air Defense System modernization — a concern of **Marty Haas**, who is with the electronic Systems Division, Air Force Systems Command, Hanscom Air Force Base, Bedford, Mass. His group is in the seventh year of a ten-year program which is part of the Base Rights Agreement which allows us to have air bases in Spain. Son Steve is looking forward to going to Cornell this fall in environmental engineering; daughter Marilyn has just finished at Chamerlayne Junior College in interior design and is a department manager in a hardware/wallcovering sotre. Marty's older son Jeffrey is married and has made Marty a grandfather already. Golf occupies Marty's spare time at a country club near Reading, Mass.

Fred Brodersen was Director of Development at the Deaconess Hospital in Cincinnati, Ohio, at the time of his death last December (reported in the May issue). He was the editor of the house paper *Deacon News* and, in addition, his responsibilities included fund raising. He was active in

many alumni activities, particularly the Alumni Fund Drive. He leaves his wife, a married daughter, and a son and daughter still at home. We send our sympathy to Mrs. Brodersen and the family.

Aaron Newman is a Manager of Projects for Ebasco Services, Inc., which has massive projects in the area of power plant design and construction. Aaron's projects include (among others) the engineering design and construction management of the two-unit nuclear power plant in Mexico, the engineering and design responsibility for a coal-fired power plant in the desert 300 miles northeast of Phoenix, Ariz., and projects in Brazil for which the company has peripheral responsibilities. Aaron started his career at the Brooklyn Navy Yard, went with Electric Boat, was an architect engineer for Spanish Bases in Madrid, Spain, then joined Ebasco Services and Parsons-Jorden Corp., New York City. In 1969, he received the M.B.A. degree from New York University Graduate School of Business Administration.

A report from **Claude Brenner**: "Mary and I and the children spent two weeks in England during April for a variety of family celebrations. Mary stayed an additional week and, while passing through Heathrow Airport, she ran into Karen and **Jack Rizika** who were on their way to Israel. There is a double coincidence here in that Jack has a home in Radlett, Hertfortshire, a village 20 miles north of London in which Mary's sister and her family live. Unfortunately, it didn't occur to us that the Rizikas might be there at the same time as we were."

And from the peripatetic **Arnold Judson**: "Greetings from down under! June and I are guests for a week at the Young Presidents Organization where I am giving three seminars on productivity improvement. Sydney is a far more lovely city than we had visualized — a sort of San Francisco setting — but very, very remote from everything. The week has been packed with an interesting diversity of seminars, some given by quite impressive people, and incredible social events, not the least of which was a gala opening convocation in the Opera House complete with 'Highland' pipers, symphony orchestra, and aboriginal dancing. Next week we're moving on to Bali for a week, then Hong Kong, Maui, and back to Boston on Mothers' Day!"

Joe Riley and **Art Schwartz** bring our number to 14 in the seventh row of 10-250.

Norm Holland writes, "After taking my Ph.D. in English literature at Harvard (1956), I taught literature at M.I.T. for a while. In 1966 I moved to the University of the State of New York at Buffalo, at first to chair the English Department, later to simply profess, and except for a year in Paris, I've been here since. I'm the author of a lot of professional articles and six books, including *Poems in Person* (1973), a psychological study of the processes of creation and response. In 1970 I founded The Center for the Psychological Study of the Arts at S.U.N.Y. which involves about ten of us plus a score of graduate students. We are the only such center in the world, so far as I know, and we have been written up quite a bit in Europe and Japan. Our two visiting scholars next year come from Belgium and Australia. On the family side, my wife Jane works as a researcher in the social sciences, currently with Planned Parenthood. Kathy (19) is a sophomore at Amherst College, while John (17) is a gifted jazz painist, attending high school and, in the summers, the Eastman School of Music. Buffalo is beautiful in the summer (defined hereabouts as three weeks of bad ice skating) and Jane and I would enjoy helping anyone visiting this frontier to look at Niagara Falls or the Albright-Knox Gallery."

Many thanks to all who have contributed to our mid-summer reading. May you all be inspired to take up your pens and do likewise! — **Ginny Grammer**, Secretary, 62 Sullivan St., Charlestown, Mass. 02129

48

Ken Brock and Ann have been in Pleasantville, N.Y., for almost a year. Ken is Vice President for Development and Public Affairs of the Institute of International Education. The Institute administers funds for many educational exchange programs, and maintains a library of catalogs from universities throughout the world. The Institute also administers the Fulbright fellowship program.

Ann made a delightful dinner and Ken broiled steaks when I visitied in March. Charlie, their son, has been accepted at M.I.T. and will be a freshman in the fall. Their daughter, Lee, is enjoying high school in Pleasantville. Ann and Ken's house is on a high ridge looking west to the Hudson River valley. Their large yard is surrounded with the evergreens that the former owner planted after every Christmas.

Bernie Gordon's company Analogic Inc. of Wakefield, Mass., is growing so rapidly that by the time you read this news, the numbers will be out-of-date. For example, sales now at $40 million rate were running $16 million just last July. In that period employment increased to 700 people from around 300 people.

Analogic is the new name of Gordon Engineering Co. (GEC). Prior to founding and building Analogic, Bernie had founded and built another company, Epsco, Inc., which has had continued success since Bernie sold his interests.

Bernie described how he personally leads the product design group in the establishment of a professional partnership between the customer and Analogic. After an intensive development period, the product is uniquely designed for the needs of the customer. A recent development is Computerized Axial Tomography (CAT) which speeds up the computation and display of medical information images revealing conditions not previously directly observable. If I understand tomography the image is created with x-ray equipment and sensors. The display shows a particular plane in the patient's tissue.

Bernie and his management team are making plans to retain the ability to technically innovate rapidly while providing the additional people needed for the growth of their business. New plant facilities will be available in a few months.

George Macomber served four years as Chairman of the Board of Emerson Hospital and has retired from that job. He just became a member of the M.I.T. visiting committee on athletics.

Marshall Dick is living in Potomac, Md. His son Stephen is in the Army at Fort Stewart, Ga. His daughter Allison will graduate high school this year, and his son Jonathan is having a ball in kindergarten. (Remember Marshall earned a record of sorts among '48ers when Jonathan was born in 1973.) Marshall's wife Kathy is active in their local temple and the League of Woman Voters. Marshall is trying to save the environment from industrial pollution at his job with E.P.A.

Harrison Rowe has received the David Sarnoff Award from the Institute of Electrical and Electronics Engineers (I.E.E.E.). Harrison is at Bell Labs where he does research on radio communications. Harrison and Jack E. Manley were recognized for their work on the properties of non-linear devices resulting in the well-known Manley-Rowe Relations. The Manley-Rowe Relations are a set of equations that apply to many processes in which energy is exchanged at different frequencies. The Relations have been particularly helpful in both understanding and developing very low-noise amplifiers known as parametric amplifiers. These devices are used in the ground station receivers of satellite communications systems, and in microwave receivers for radio astronomy and radar.

Elton Hammond is entering his 30th year with Westinghouse, 18 of which he spent in Lima, Ohio, at the Aerospace Electric Division. He has been president of the Lima Council, American Youth Hostels for three years. After 28 years of duty in the Reserve including three years of active duty during World War II, Elton retired as Lt. Colonel from Civil Engineers, U.S.A.R. His wife recently earned a degree at Ohio Northern; oldest daughter earned a Ph.D. at Brandeis; second daughter earned master's from University of Virginia; their oldest son received his bachelor's from Colorado University; youngest son is a junior at Ohio Northern. His oldest daughter plays bassoon with the M.I.T. string ensemble and teaches at Wheaton.

Joe Corso won the Chief Engineer's Technical Excellence Award at RCA for having distinguished himself in work on the U.S. Navy's program for an advanced electronics guided-intercept system that is being built by RCA for the government. . . . Motorola has joined M.I.T.'s cooperative program in the Department of Electrical Engineering and Computer Science (Course VI-A). **Bill Weisz**, Motorola's president, participated in the initial discussions last year. . . . **Ed Kratovil** is enjoying his new role as Carolina Gentleman Farmer.

Harry Davis is Professor of Mathematics at the University of Waterloo in Ontario. Harry wrote **Graham Sterling** that he has been relatively happy and will be even more so if he can get the book he is now writing finished and through the press. . . . **Bill Katz** is Vice President of Sales at Ionics, Inc. Bill's group sells systems that remove salts from water. Their systems are used throughout the world to purify brackish water for domestic and industrial uses. Ionics' sales have grown to the level where they are squeezed for space in their present building in Watertown. Bill travels to the Middle East, the southwest, and to islands everywhere as the world's needs for pure water exceeds the available supply. Ionics' system uses electrodialysis to remove salt ions from water flowing between closely spaced membranes. The membranes are assembled in stacks and a d.c. voltage is applied.

Robert B. Charney has been at Union Data Service Center since 1966. It is the data processing subsidiary of the Union Service group of Mutual Funds. In April, 1977 he moved from Manager of Systems and Programming to Coordinator of Systems and Programming Technology. His daughter is finishing medical school and his second son is in first-year law. He and his wife have moved to a smaller apartment six blocks from Lincoln Center for the Perfoming Arts in New York City. They walk to their opera and ballet seats.

Warren E. Johnson is a part-time instructor in the cinema department at the University of Bridgeport's College of Fine Arts. Warren has made more than 22 films on subjects ranging from the new art center in France to voter registration. He is co-author of a text book for high school and college students on making movies, and has worked in the film department of the Museum of Modern Art in New York City. — **S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

49

Jack L. Baker leds off with the first of two alumni fund notes: "Completed seventh year and 235th placement as executive recruiter for management recruiters of Ann Arbor, Mich. It's more fun to match the right person to the right job than it is to do the job personally. This is a recommended second career for those whose first career was deflected by shifts in federal spending, and need the challenge." . . . **Robert O. Bigelow** reports that his daughter Peggy Taylor is finishing up an M.B.A. program at M.I.T.'s Sloan School. He has been living in Southboro, Mass., since 1969 and was elected Vice President, New England Power Service Co. in June, 1977.

From a news clipping, I learned (what I had missed last December) that **Stan Margolin** is now a fellow of the American Institute of Chemical Engineers. He was elected in recognition of his work in Chemical Engineering, Process Metallurgy, and Technical and Economic studies. Congratulations, Stan. . . . Another form of recognition, the 1977 A.A.A.S. Westinghouse Science Writing Award for newspapers with more than 100,000 daily circulation, went to **Robert C. Cowen**, science editor of the *Christian Science Monitor*, for his series entitled, "Coping with Nature's Forces." Bob writes regularly on Technology and Science for the *Technology Review*. He calls himself "a poet of nature," and his two degrees from M.I.T. and over 25 years of journalistic experience have solidified his conviction that

people want to understand the sciences, yet find them confusing and sometimes frightening. In his award-winning series on facing natural disasters, he both explains such natural earth forces as storms and earthquakes and goes on to illustrate how we can anticipate and take precautions to prevent major catastrophes.

Walter E. Morrow, Jr., director of Lincoln Laboratory since March, 1977, was appointed Professor of Electrical Engineering in the Department of Electrical Engineering and Computer Science.

Finally, another classmate has died: **Joseph R. Altieri**, on January 27 of this year. A consulting engineer, he lived in Springfield, Vt. I have no other information at this time.

Best wishes to all for an enjoyable summer. Don't forget to plan for the 30th Reunion next June. — **Frank T. Hulswit**, Secretary, 77 Temple Rd., Concord, Mass. 01742

50

Malcolm Green is presently President of Datametrics Co., located in Wilmington, Mass. Mal joined what is now Datametrics in June of 1977 when it was part of I.T.E. Imperial. Gould, Inc., acquired I.T.E. in April of 1976 and recently began to divest themselves of some of the operations. Mal, together with two associates, was able to acquire Datametrics on January 1, 1978. He finds it a challenging and stimulating activity. The product lines include pressure, vacuum and flow measuring systems; time code generators; and Trump-Ross encoders. Three new products are due to be announced before May 1. Along the home front, his son Richard will graduate in June from the University of Denver where he is studying hotel and restaurant management. Daughter Carol is a sophomore at Trinity College in Connecticut where she is coxswain of the men's JV lightweight crew, and Diane is a junior at Newton North High School. Mal's wife Susan went back to Simmons and got a master's in management a couple of years ago. She is now employed by the Massachusetts Association of School Business Officials where, among other projects, she helps school systems computerize their financial management techniques. — **John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

53

By the time you read this our 25th Reunion will have become past history. A full report on it will be forthcoming, I am sure, from the new class secretary. In the meantime, let me empty my mailbag.

John Morgenstern has left the Bedford office of MITRE Corp. (where he led several system engineering departments in the command, control and communications fields) to join the staff of the Secretary of Defense as the Director for Strategic and Theatre Command and Control. John reports to the Under-Secretary for Research and Engineering, and will (among other matters) be responsible for research and engineering of a number of important programs which support both our offensive and defensive strategic forces. . . . Early in March, **George Wallace**, now living in Hendersonville, N.C., became vice president-administration of Olin Corp., as well as an officer of the corporation. Prior to this appointment, he was vice president - manufacturing of the Ecusta Paper and Film Group of Olin. . . . The following succinct report was received from **Moe Torti**: "Working as research manager on high-strength ceramic components for energy conversion systems at Norton Co. in Worcester, Mass. Married, living in Lincoln, Mass., in rural setting where I'm having lots of fun gardening, cross-country skiing, etc."

The New England Engineering Journal recently ran a lengthy "Personality of the Month" article on none other than **Joe Molloy**. Joe is extremely active — both at work (at the Charles Stark Draper Lab) and away from work — in assisting handicapped people. For one, he's working on a project devising "remote button pushers" to aid those who cannot reach the buttons which activate exhibits at museums. For another, he is involved in making air travel more accessible to the handicapped. His interest in these activities is quite natural — if one knows that Joe had a pilot's license and was a qualified instructor prior to his unfortunate and unrelenting battle with multiple sclerosis which has seen him move from crutches, to a wheelchair, and now to a motorized wheelchair. . . . **Rudy Kalman** is currently a professor at the Swiss Federal Institute of Technology in Zurich, though he is returning during May to attend a conference here in Pittsburgh on guess what? Yep. Kalman filtering.

Lastly, I am sorry to report that **Walter Dedrick** (who was a rear admiral) died late last September. — **Martin Wohl**, Secretary, 7520 Carriage Ln., Pittsburgh, Penn. 15221

54

Where will *you* be in just about a year from now? At the Class of 1954's 25th Reunion, we hope. Back to the campus that many of us left reluctantly, many joyfully, all of us somehow changed by M.I.T.'s influence.

Alex Dreyfoos will be there. He writes, "I am enjoying the single life style in Palm Beach, flying, boating, and fishing. Completed development and brought to market a laser color photographic printer for making very high quality prints from slides. TV station (ABC in West Palm Beach) had an excellent year. Acquired and am expanding a marina. Looking forward to 25th reunion but would welcome seeing old friends who get to Palm Beach area before then." So, visit Alex in Florida and join all of us in Cambridge.

Anthony Turano left Exxon in Houston about a year ago and joined TOSCO Corp. in Los Angeles. He is Senior V. P. Administrator for Lion Oil Co., a division of TOSCO, and is concerned with financial analysis, budgeting and controls. . . . **David Whitehouse** recently invented a method of energizing a laser source by stimulating a flashlamp directly from an active current power line. Dr. Whitehouse manages laser development for Raytheon. . . . **Dean Jacoby** met recently with **Bob Anslow**, our 25th Reunion Gift Chairman, in London, England, to discuss reunion gift fund raising. Both Dean and Bob were in England on business. — **Dave Howes**, Secretary, Box 66, Carlisle, Mass. 01741; Assistant Secretaies: **Chuck Masison**, 76 Spellman Rd., Westwood, Mass. 02090; **Lou Mahoney**, 6 Danby Rd., Stoneham, Mass. 02180

55

In March your class officers met to start planning our 25th reunion. The main topic was the search for an appropriate class gift. After considerable investigation and discussion, the idea that met with the most favor was the renovation of Room 10-250. The lecture hall represents a common locus of all M.I.T. undergraduates of our period, and the refurbishing and improvement of the hall would be a significant gift to the Institute by our class. The topic of the class gift is still being debated, and your views are welcome. **Pete Toohy**, **Ed Erlich**, **Denny Shapiro**, and **Rick Morgenthaler** would like to hear from you.

Just to get you in the reunion spirit, I'll share a letter from Edie and **Bob Greene**, who are a long way from Cambridge, but still very much a part of the class:

"Greetings from the Cairo Greene's — address: c/o M.I.T./T.A.P./Egypt; Room 1-173; Massachusetts Institute of Technology; 77 Massachusetts Ave; Cambridge, Mass. 02139. (Our mail is hand-carried by project participants who come to Cairo about once a month.)Bob is the M.I.T. Administrative Officer for the M.I.T./Cairo University Technological Planning Program. The U.S.A.I.D.-funded program is conducting currently 11 joint research projects ranging from traffic to health care. We work an Egyptian schedule — six days a week

The U.S. is nowhere near running out of energy, says S. William Gouse, '53, Chief Scientist for MITRE Corp. Indeed, resources which Dr. Gouse himself identified are adequate to render the U.S. self-sufficient — no imports at all — by 1990 if energy can seek its true market value and prices are allowed to rise. (Photo: Louis B. Nocca from MITRE Corp.)

Marked copy to Tom Curran, Editor, Mitre Matters, Mitre Corp. Bedford, Mass. 01730

How Fossil Fuels Can Solve Our Third "Energy Problem"

"[illegible] in the middle of [illegible] problem," says S. William Gouse, '53, Chief Scientist for MITRE Corp. The first one was solved in the 1920s, when oil was discovered in Texas; the second one, in the 1940s, was "wiped out" when Saudi Arabian oil production began.

"There may be a surprise this time, too," Dr. Gouse told a MITRE Corp. meeting early this spring.

The kind of "surprise" Dr. Gouse had in mind is suggested when you know that his former job — before coming to MITRE Corp. last year — was Assistant Administrator for Fossil Fuels in the Energy Research and Development Administration. Much of Dr. Gouse's MITRE presentation was devoted to a review of U.S. fossil resources.

—Peat is an untouched resource in the U.S., and there are plentiful supplies in Minnesota and North Carolina. In Ireland, Russia, and other parts of Europe peat is dried and burned to generate electricity; and the land underneath turns out to be more productive after removal of the peat than it was before.

—The production of coal in the U.S. could be doubled by 1985. Political and economic factors — not technological ones — must be resolved if that goal is to be achieved.

—Productive deep gas wells have recently been drilled in Pennsylvania and along the Gulf coast; the only problem is the cost of drilling to depths of 12,000 feet and more.

If all these and other resources were brought into use by 1990, energy imports could be a thing of the past, Dr. Gouse told his MITRE audience.

M.I.T. on the Great Wall of China. Walter P. Frey, '56, carried the M.I.T. message when he went to the People's Republic of China early this year, and a friend made this picture to prove it. Mr. Frey, who is associated with Mobil Sales and Supply Corp., was in the People's Republic for consultations with the Chinese airline and the military air force.

When the M.I.T. Club of Chicago decided to host a conference on "Management's Challenge in the 1980's" on May 8 (see page A26), the task of Chairman fell to Richard A. Jacobs, '56 (right), who headed a committee of ten hard-working club members. Among the latter: John W. Barriger, '49 (left), who had headed planning for an equally sucessful previous Club conference.

from 8:00 to 2:00 with no lunch break — Fridays off.

"Ann is with us, enjoying tennis lessons, photography class; and her senior year at Cairo American College — the American high school. Pat, a junior at Cornell, is doing field work in social work this year. Brenda is a freshman, bio chem major, at University of New Hampshire. They both swim for the teams.

"We are having another spectacular experience in Cairo — the challenges are never-ending. Each day offers a new adventure with various surprises. The main problem is the dust and noise. There is little rain and the desert breezes send a fine dust constantly. The traffic is indescribable with traffic jams and constant horns blaring — donkey carts, overloaded buses, occasional camels, and people walking and running in and out.

"We live in the suburb of Maadi (about seven miles from the office) which is a quiet area where many expatriates live because the American school is here. During the warm weather, we hit a few spots on our Fridays off — the Sphinx and Pyramids at Giza; Alexandria; El Ellimain; Ismallia on the Suez Canal. We just spent four days in Greece over the Moslem holidays when the office was closed and we couldn't work. We plan to go to Luxor in Upper Egypt when Pat and Brenda get here for Christmas vacation." — Co-Secretaries: **Marc S. Gross**, 15 Franklin Ct., Ardsley, N.Y. 10502; **Allan C. Schell**, 19 Wedgemere Ave., Winchester, Mass. 01890

56

Jim Allen is now assistant chief in the Structural Division of Stone and Webster, Inc. . . . **Richard Carlson** has left Arthur D. Little Inc., to become Vice President of the First East Savings Bank of Lynn, Mass. . . . **Fred Culick** writes that he combines teaching, research, and consulting as Professor of Engineering and Applied Physics at Caltech, specializing in rockets and lasers. He and Fritzie are half-owners of a skating rink in Pasadena, which enables him to teach and play hockey regularly. Then there is a one-third-owned Cessna 206 used for pleasure and consulting travel. . . . **Dimitri Manthos** is now Vice President of Tropic Drilling and Exploration Co., offshore contractors based in London.

Dr. **Paul Polishuk**, formerly President of Horizon House International and before that Deputy Director of the Office of Telecommunications in the U.S. Department of Commerce, has formed a new company, Information Gatekeepers, Inc. The new firm is a multi-media publishing and marketing organization with emphasis on international activities for the computer-communications industry. . . . **John Seeger** is back from a year in London where he gathered data for a doctoral thesis on problem-solving in management meetings. . . . **Craig Sherbrooke** is a Vice President of Mathematica, Inc., directing a team that performs inter-disciplinary research for the intelligence community. Craig is another part-time hockey player (Washington area). — Co-Secretaries: **Bruce B. Bredehoft**, 7100 Lanham Ln., Edina, Minn. 55435; **Warren G. Briggs**, Deree College, Box 472, Athens, Greece (to July, 1978).

57

The editors have just learned that **Guy A. Carbone** of Watertown, Mass., has announced his candidacy for the Democratic nomination to the office of District Attorney of Middlesex County. Elections will be held in the fall of 1978.

He is currently Senior Counsel for the Com-

monwealth of Massachusetts Department of Labor and Industry and former Chief Engineer for the Governmnet Center Commission. He has also been elected to the Watertown School Board for four terms and is presently a Watertown Selectman. — *S.K.*

58

Despite the excitement of the Reunion, or just possibly because of it, news wires continue to buzz at our message center. **Dan Holland** has just been elected chief executive of the new Massachusetts Capital Resource Co., an organization formed to meet the financial needs of firms in the state for the creation or retention of jobs. Until this appointment, Dan was with the Boston office of the First National Bank of Chicago. Previously he was at American Research and Development with responsibility for recommending investments in small, high-technology companies. Dan and Pat now have seven children and still live in Hingham ... At Time, Inc., **Deane Raley** has been named Director of Labor Relations. Formerly he was the General Manager of Time's Magazine Development Group. Deane received his M.A. from the University of Chicago in 1959 and joined Time in 1962 in their Manufacturing and Distribution Department. Deane and Dru have two daughters and are living in Pound Ridge, N.Y. ... A brief note on the family scene arrived from **Arthur Zimmet** and his wife — they have added a third son to the clan ... In Montgomery, Ala., Major **Charles Rogers** was awarded the Meritorious Service Medal at Maxwell Air Force Base. He was cited for outstanding performance as Chief of the Technology Unit with the 1155th Technical Squadron.

More entrepreneuers in the class ranks. And what a varied crop! First we heard from **Jason Taylor** that he has formed a free-lance writing company specializing in articles about computer applications. Named, appropriately enough, Taylor Associates, the firm has already published three books: *The Calculus With Analytic Geometry Handbook*; *A Collection of Brain Ticklers for Everyone*; and *Study Guide for An Elementary Approach to Functions* (the latter published by McGraw-Hill). ... Next, **Alton Frabetti** has formed a consulting firm, Applied Resources, which specializes in energy analysis and conservation, solar heating systems, and environmental engineering. Located in Hyannis, the firm will serve government, industrial, and consumer clients ... Finally, **Ken Langley** has founded a new company, Langley-Ford Instruments, with Norman Ford, Jr., '53. Their firm will design, manufacture, and market electronic instruments and systems. Currently, they are marketing a digital correlator used with laser light scattering to measure diffusion coefficients of molecules in solution and in laser Doppler velocimetry. According to Ken's note, "Things are going well and the business is growing rapidly." ... On a recent trip to the Hartford area, I had dinner with Pat and **Larry Boedeker**, along with their two young sons, Tom and Steven. Larry is still doing solid engineering and research work at Pratt and Whitney, having managed to escape the joys (?) of management and administration. Ah, remember how it was? — **Michael E. Brose**, Secretary, 30 Dartmouth St., Boston, Mass. 02116

59

Two parts to this month's column — news collected here in the Boston area, and a report filed by our overseas correspondent reporting from Indonesia.

Congratulations to: **Larry Roberts** of Telenet Communications in Washington, D.C., who was recently elected to the National Academy of Engineering; and **Bill Finneran**, elected to the State Assembly of New York as a representative from Westchester, who was also elected President of the Freshman Class of the State Assembly.

William Towle, about whom we heard during his tenure with the World Health Organization in New Delhi, India, has joined Analytic Sciences Corp. in Washington, D.C., where he is working on policy studies and international health. ... Our London office in the person of **Jerry Schooler** notes that he was made a Fellow of the Royal Society of Health, is serving as Treasurer of the British Heart Foundation in Westminster, and was an invited speaker at a recent conference of the Greater London Council for Home Safety. However, the most important part of his note concerns his oenological (Class Notes can build your vocabulary!) talents. He has recently been made an Honorary Citizen of the Ancient Order of the Grand Duchy of Artimino, Italy, for his professional winetasting capabilities.

In Springfield, Mass., **Wayne Stuart** was elected Senior Vice President of the Farm Credit Banks. The local newspaper article noted that Wayne had done graduate work at the Harvard Business School and has been with the bank since 1973.

On the technical scene, **Frank Von Hippel**, who is with the Center for Environmental Studies at Princeton, recently presented "Changing the Path of Least Resistance" to the Symposium on Whistle-Blowing and Scientific Responsibility: The Management of Technical Dissent in the Food and Drug Administration at the annual meeting of the American Association for the Advancement of Science. ... **Gilbert Chin** was one of four named by Bell Laboratories as inventors of a new magnetic alloy which will be used in telephone receivers to convert electrical signals into speech. The new alloy is called Chromindur.

From **Adul Pinsuvana** in Jakarta: "It has been a little over one year now since my arrival in Jakarta. During this time I have quite enjoyed my job as the First Administrative Officer of the newly created A.S.E.A.N. Secretariat. The job is quite exciting, and the new surroundings of Jakarta also have a stimulating effect on our family after having been stable in Bangkok for many years.

"I am almost at a loss for any news of our classmates. One note about a fellow Thai, **Subin Banharnsupavat**, who sent me a note from Long Beach, Calif., where he now lives: He is a senior engineer for Bechtel Power Corp. Those who remember him from the soccer team may be interested to know that he has picked up a Ph.D., probably in nuclear engineering, in addition to a couple of M.S. degrees in mechanical and nuclear engineering. He is still single.

"Another former East Campus friend that wrote me from West Virginia is **Irvin Van Horn**. Irvin is working in a chemical plant, heading a group supporting a production activity. He told me of his active involvement with the Boy Scouts and his new hobby, bicycling. Irvin is another who is still single."

Unfortunately, I relate the death of **Allen Chertoff** this past January in New York. Allen was an electrical engineering graduate who participated in the activities of the M.I.T. Alumni Center of New York. The sympathies of the class are extended to the Chertoff family.

We are now about one year away from our 20th reunion. Our objective is to maintain a full column of notes each month. We need your assistance. Let us hear from you by dropping a line or two to **Phil Richardson**, 180 Riverside Dr., New York, N.Y. 10024; **John Amrein**, 770 Greenwood Ave., Glencoe, Ill. 60022; **Adul Pinsuvana**, A.S.E.A.N. Secretariat, 6 Jalan Taman Pejambon, Jakarta, Indonesia; **Bob Muh**, 907 Chantilly Rd., Los Angeles, Calif. 90024; or **Allan Bufferd**, 8 Whitney Rd., Newtonville, Mass. 02160

61

Just a few notes this month. They indicate how varied the paths of our Class have been over the years. **Steve Salomon** is in Washington, D.C., working for the Nuclear Regulatory Commission "toward a more efficient and effective licensing process for nuclear power plants." No doubt we have classmates who are picketing some of the plants Steve is in the process of licensing! He says that Washington is still an exciting place to be these days. ... **Bob Pease** has left Massachusetts for good, it seems, and is working for National Semiconductor out in sunny California. He reports that his first new power product is the "LM 137, a versatile negative power regulator which is now in full production. I had to learn a lot to get it running (old dogs, new tricks)." ... **E. Viet Howard** writes that he recently became President of the Bunker Hill Co., in Kellog, Idaho, a major U.S. producer of lead, zinc, and silver. "The skiing is great in Northern Idaho!" he says. ... Finally **Ben Turetzky** has given up local politics and moved west. He finished a two-year term as the Township Council President in Parsippany, N.J., on New Years Eve, and on January 3, the whole Turetzky crew moved out to Beaumont, Tex., where Ben still works for Texas U.S. Chemical as a senior research scientist. — **Andrew Braun**, Secretary, 464 Heath St., Chestnut Hill, Mass. 02167

62

Jerry L. Adams was re-elected in November to his third term on Athens, Ohio, City Council. In January he was re-elected President Pro-tem of council. He is still enjoying being an Associate Professor of Physics at Ohio University. He is co-author of a physical science freshman level text which has sold over 50,000 copies nationwide. ... **Harvey E. Cline** and two other scientists at the General Electric Research and Development Center were honored recently at a special inventor-recognition ceremony. The three inventors, who have been awarded 50 patents apiece, each received an award plaque and a bound volume of his own patents — **Gerald L. Katell**, Secretary, 7 Silverbit Ln., Rolling Hills Estates, Calif. 90274

63

By the time most of you read this many of us will have been re-united once again on the banks of the Charles and walked many of the same corridors that we walked over 15 years ago. I'm sure that a number of us will have visited the library to have a look at our undergraduate theses. These reunions of ours are a strange blend of past and present. We will be stimulated by the symposia and programs planned for us in the present, amazed by the changes in Cambridge, Boston, and M.I.T., and, of course, be surprised at the changes in manner and appearance of our old friends. At the same time waves of nostalgia will sweep over us — particularly this year, when the reunion is on the campus. What kinds of memories will be there for us, jarred loose by those same sights and sensations we experienced so long ago.

Well, so much for June. This is April, and I have some notes to transmit to you of events that took place in January, February, and March. I received a real letter this March from **John Wasserlein**. He writes that, in addition to his regular duties as Division Manager of the Specialty Paperboard Division of Boise Cascade in Brattleboro, Vt., and being president of five subsidiary corporations, he has recently been named president of the Beaver Falls Power Co. The Wasserleins also welcomed a daughter, Deborah Eve, to their family on February 22 of this year.

Also had a note from John Nolan which contained a brochure for a product made by John's company. The device is a water-powered bath chair to be used by disabled persons. ... My batch of envelope flaps this month contained the news that **Mike Chessman** moved from Boston to San Francisco last December. Mike is now working for Amdahl Corp. His family includes his wife and two daughters, aged 8, and 2. ... **Robert Osborne** recently joined Kleffman Electronics, Inc., as manager of system software. K.E.I. develops and builds computer peripheral subsystems for C.D.C. computers. ... **Kenan E. Sahin** reports that he spent 1976-77 at the Harvard School of Public Health as a visiting lecturer. Half his appointment was in the Harvard Center for the Analysis of Health Practices and the other half was in the Graduate Program in Health Policy.

The good wishes of Dean Carola Eisenberg (left) and a host of friends went with Kenneth C. Browning, '66, Associate Dean for Student Affairs, when he left M.I.T. this spring. His destination was Grinnell, Iowa, where He's now Vice Provost of Grinnell College.

With chagrin, the Editors report a case of mistaken identity when this picture was first published in Technology Review *for March/April, 1978 (page B15). The subjects — both guests at a special opening of the Stephen Wirtz Gallery in San Francisco for members of the M.I.T. Club of Northern California to see photographs by Professor Harold E. Edgerton, Sc.D. '31 — are Richard A. Blanchard, '68, Vice President of the Club, and Frances Hurisu. The* Review *regrets confusion and possible embarrassments.*

The year was capped with a teaching award from the students. He also mentions that he received patents from the United Kingdom and Canada for his Selcuk networks for computer communication and pattern recognition.

Finally, a press release from Bell Labs in Murray Hill, N.J., informs us that **Bud Wonsiewicz**, along with Gilbert Chin, '59, and two others have invented a metal alloy that may substantially cut the manufacturing cost of magnets used in ring armature-type telephone receivers. The material, called Chromindur, is an alloy of chromium, colbalt, and iron. It has greater strength and better magnetic properties than the alloy now in use. A major advantage of Chromindur is that it is cold-formable, speeding production of the magnets used in telephones and other products where high-performance magnetic alloys are used.

Hope to see many of you in Cambridge this June. Enjoy your summers. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92715

64

Greetings, classmates. This month has proven the wisdom of saving two of our class heroes from last month. The notice of our current deadline came with a scant envelope or two, just the day before Marlene and I were leaving for a business trip of mine and a nice little vacation for her, and Marlene managed to misplace them in the last-minute confusion. So, to those one or two of you who look in vain on these pages for mention of your events, please forgive us. If our continued search of the nooks and crannies in our house turn up your inputs, you shall surely see them in some future issue.

Richard J. Adamec has just been promoted to Director of the Product Planning and Research Group of Dun and Bradstreet, Inc. Dick's department is responsible for new business development, corporate planning, and market research, and he personally directs the activities of ten professionals. He has been using the results of some Sloan School research on innovation in industrial products, and he mentions how very helpful those efforts have been to him in his work.

Our second class hero, **John Meriwether**, sent us a nice postcard (I didn't know anybody could get so much on a postcard) from Carite Lake, Guayama, Puerto Rico, February 16. About half of the card is given over to describing the balmy, delightful weather and the many trips he and Erika take to the beach, with lots of commiserating over "the poor, poor people in the northern hinterlands at this time of the year." By the time you read this, John will probably be on his way to Bulgaria for the summer, where he is an invited speaker at a U.S.-Eastern European symposium on atmospheric airglow (if I can read John's handwriting). On the way, he may have to detour via Innsbruck, Austria, to present two technical papers. (I really wish I could include a picture of this lake!)

We just returned from nine days in California, attending a major Industry/Joint Services conference on automatic testing and visiting some relatives and old friends on side trips. Except for the very bumpy final half-hour of the plane ride home, all went well. Just this past weekend we spent a lovely evening with Ellen and **Gary Walpert** and Marilyn and Don Goldman ('65), highlighted by a delicious dinner at the "1789" restaurant in Georgetown and followed by a "sort-of" late-night tour of the local memorabilia (White House, Capitol, memorials, etc.).

We're only 12 months from our 15-year reunion. Boy, how the time flies when you're having fun. Stay well and write. — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, Md. 20954

65

Lilian and **Dave Carrier** note the addition of a new member of their family, Kristina Alicia. Dave has left Bechtel and is now working for Woodward-Clyde Consultants in San Francisco. . . . Also in a new job is **Jerry Robertson**; when last heard of, Susan and Jerry and their three children were in Ireland, where Jerry was working for Northern Telcom. He is now Engineering Manager for Unex Laboratories of Danvers. . . . **Barry Wessler** has been elected Vice President of Telenet Communications Corp. in Washington. D.C. . . . The Power Systems Group of Combustion Engineering, Inc., announced **John Matton**'s appointment as District Manager of the Detroit office. . . . Another announced promotion is that of **Michael Adler**, to be manager of the Archival Memory Program at the General Electric Research and Development Center. . . . **Jim Wolf** has been elected a Vice President of Booz-Allen and Hamilton, the consulting firm that seems to be a very Tech-dominated organization by the sound of these columns of late.

John Raney is presently vice chairman of the statewide citizens' forum for the Hawaii coastal zone management program. . . . **Larry Stark** received the 1977 Morlock Award for his work in the field of electrical engineering applications to neurology. Dr. Stark is Professor of Physiological Optics at Berkeley.

This column was mostly news clippings and press releases (and sounded like it, on rereading). Let's try for some Class Heroes for next time! — **Edward P. Hoffer**, M.D., Secretary, 12 Upland Rd., Wellesley, Mass. 02181

66

The big news this month comes from Cambridge. **Ken Browning** has accepted the position of Vice Provost of Grinnell College in Grinnell, Iowa, and left the Institute in April to assume this new position on May 1. Ken has been the Associate Dean for Student Affairs since 1971 and has been associated with the Institute since we all first got to Cambridge back in 1972. Ken will be the chief assistant to the Provost and Dean of the college and will have responsibilities very similar to those of Chancellor Paul Gray of M.I.T. These responsibilities will include budgeting, physical plant, food service, and the book store. Ken will continue as class President and invites any and all alumni to visit Grinnell, Iowa, just off of Interstate 80. Ken and his wife, Jane, will be living at 1233 Park St., Grinnell, Iowa 50112 until July 31 and 1409 Broad St., Grinnell, Iowa 50112 thereafter. I know we all extend congratulations to Ken on his promotion and best wishes at Grinnell.

Lew Gaines, who is with Exxon Enterprises, presented a paper on lithium-titanium disulfide at the A.A.A.S. annual meeting February, 1978. While I was sent the synopsis of the paper, I am not sure that I understand the chemistry involved. So much for my experience in 5.01 and 5.02. The project is designed to develop battery systems for practicable electric vehicles. . . . **Jim Kester** was promoted to Major in the U.S. Air Force. He and his, Esther, are at the Offutt Air Force Base in Nebraska where Jim is an advanced weather officer of the Military Airlift Command. . . . **Melvyn Kassenoff** writes that he is currently a Senior Patent Attorney with Sandoz. . . . **David Nicoli** writes that he is an Assistant Professor of Physics teaching instrumentation electronics for the master's program in scientific instrumentation.

Got a card from **Ken Caneva** in Amsterdam who writes that he "is still growing and changing — and living with his lover." Ken is teaching history of science there. . . . **Ron Muhlenkamp** has set up his own investment advisory firm in Bradford Woods, Penn., right outside of Pittsburgh. Ron and his wife, Connie, and their four children are living in Bradford Woods just off the intersection of I-79 and Pennsylvania Turnpike.

Mail is getting sparse, and so are columns. — **Paul Rudovsky**, Secretary, 340 East 64th St., New York, N.Y. 10021

67

After two years in surface acoustic wave filter design and product development at Teledyne in Palo Alto, Calif., **Jeff Schoenwald** will be returning to research by joining Rockwell International Science Center in Thousand Oaks, Calif. Sheri

will transfer to the School of Psychology graduate program at Northridge. . . . **Dan Hester** teaches chemistry and physics at Sacopee Valley High School in Hiram, Maine, and leads a very active high school hiking club which is planning a trip to Wyoming and Montana this summer. Dan is chairman of the local planning commission and a past chairman of the Saco River Corridor Commission. He and Linda became parents of a third daughter last June. . . . **Jim Cronburg** is in charge of public buildings maintenance in Newton, Mass. He is studying at the Boston Architectural Center and working on his thesis involving the renovation of a block in New York City and the use of videotape in architecture. . . . Nancy and **Richard Solomon** have a son, Jonathan Daniel, born February 12, 1978. . . . After an absence of four years, Annette and **Avram Markowitz** (now **Bar-Cohen**) are back in Boston. Avram is on sabbatical leave from Ben-Gurion University of the Negev in Israel where he is a Senior Lecturer in the Department of Mechanical Engineering, and is presently on staff at M.I.T.'s Energy Lab and Visiting Associate Professor in the Mechanical Engineering Department during the 1977-78 academic year. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

70

Summer is upon us and the letters trickle in like the summer's stream. **Fred Davidson** has been married for about six months and lives in Brooklyn. He says he loves marriage, and likes his home and work — designing I.M.S. data bases for Equitable Life. . . . **Paul Burstein** is also married and enjoys home ownership duties in Arlington. He is senior scientist at American Science and Engineering in Cambridge. . . . Pinball-business-only **Joseph Bisaccio** operates five penny arcades and services games on campuses and clubs throughout New England. . . . **David Thiel** remembers the blizzard in that he found time to write to us. He lives in Acton with his wife and two daughters, Rachel and Elizabeth. Dave is principal engineer in new product development for Test System Product Line at General Rad, Inc. of Concord.

Ray Kurzweil demonstrated the world's first reading machine for the blind to members of the U.S. Congress. He has secured a federal contract for production. This major advancement in humanistic technology is being done at Kurzweil Computer Products, Inc. . . . The **Vegelers** are back on the antique trail and traveling for business and pleasure. Maggie's corporate law practice is an interesting contrast to private civil practice mixed with my deputy prosecuting attorney duties. — **Robert Vegeler**, Secretary, Kennerk, Dumas, Burke and Backs, 2120 Fort Wayne National Bank Bldg., Fort Wayne, Ind. 46802

71

It is my sad duty to report the death of **John H. Peters** of 2 Ox Point Dr., Kittery, Maine 03904. . . . **David Eichler** and his wife Aviva Weisel Eichler, '74, proudly announce their son, Maor Nissan, was born this past September. . . . .**Martin Silfen** has associated with the firm of Stradley, Ronon, Stevens and Young in Philadelphia after his graduation from Villanova Law School. . . . **Manuel Weiss** has been promoted from an instructor in physical education to the faculty rank of Assistant Professor. Manny was an instructor in physical education and assistant coach of the men's tennis and squash teams after graduating in 1971. He was the first M.I.T. graduate to be a full-time coach. He was freshmen coach for men's tennis and squash from 1972 to 1976, and in 1977 he became the first full-time women's tennis coach. While at the 'tute he received the Straight T award in tennis and was captain of the tennis team. He is a committee member of the New England Women's Intercollegiate Tennis Tournament and of the M.A.I.A.W. Tennis Tournament. He is also part owner of the Accord Pond Racquet Club in Rockland. He and his wife Karen live in Duxbury.

Timothy H. DeCook is in his first year of Anesthesia Residency at Massachusetts General Hospital, while residing in Salem, Mass. His wife Bev is working in physical therapy in Danvers. . . . **Lester Byington** writes, "I've just achieved one of my material goals: I moved out of the smog to an ocean-view condominium at Redondo Beach. My commute back to General Dynamics in Pomona insures that I consume my share of gasoline." The mail bag was small this month, so write me and let all of your classmates know what you are doing. — **Hal Moorman**, Secretary, P.O. Box 1808, Brenham, Tex. 77833

72

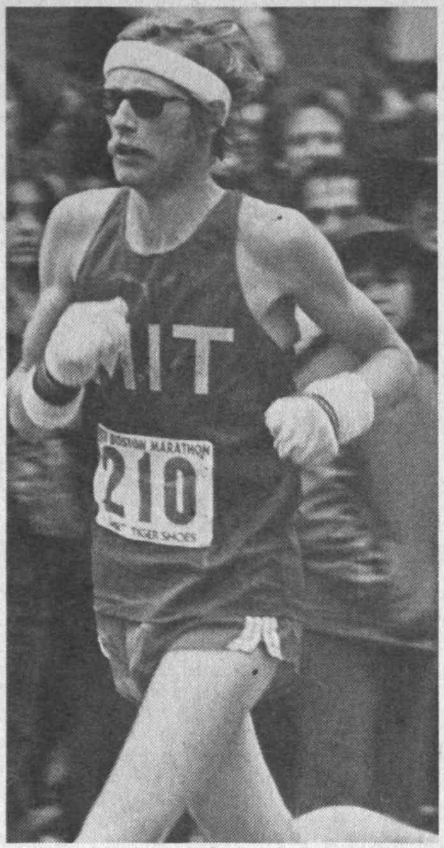
This month there is a wealth of news from and about our classmates. **Robert Ellis** married Florence York on October, 1976. His is a partner in a five-person law firm in Lorain, Ohio , and Florence is a newspaper reporter who was expecting a baby in May. . . . **Donald Rogal** is working for Hewlett-Packard as a management consultant for ten integrated circuits facilities. He got his M.B.A. from Stanford in June, 1976. . . . **Doug Bailey** expects to receive an M.B.A. from Harvard this June. . . . In March, **Kevin Trangle** graduated from the U. of Minnesota Medical School. He is doing an immunology research project, after having spent a half year at N.I.H. doing endocrinology research. He has developed a typical doctor's unreadable handwriting and plans to begin an internal medicine residency in June. . . . Another doctor, **William P. De Pietro**, writes that he is "doing a dermatology residency at St. Luke's Hospital, New York."

Last June, **Simon Wieczner** received his M.B.A. from Sloan. He is the marketing product manager at H.D.P. First Data in Waltham, Mass. . . . **John P. Cross,** a research chemist at Milliken Research Corp. in Spartanburg, S.C., is married to Virginia Cross (Ph.D. 1976). . . . **Carl Whittaker**, who left jobs with Procter and Gamble and Polaroid to pursue an M.B.A. at Amos Tuck School, looks forward to his return to industry this summer. . . . **Shirley Wilson**, in contrast, seems firmly entrenched in academia as she has now finished her second year as a math instructor at Auburn University in Montgomery, Ala. . . . **Paul Levy** has become commissioner of the Massachusetts Department of Public Utilities. If that's not enough to keep him busy he and his wife rehearse with the Tanglewood Festival Chorus which sings with the B.S.O. (according to the *Boston Herald American*).

Kathy Kram was happy to have reestablished contact with some old friends at our fifth reunion last June. She is now working on her dissertation in organization behavior at Yale, and is also teaching and consulting. In her leisure time she plays the guitar, writes songs, and hopes to play in a New Haven coffee house before she finishes her Ph.D. . . . **Irith Dror** received her Ph.D. from Columbia in May, 1978, in mathematical statistics and operations research. She plans to work on Wall Street in computer consulting. . . . **Tom Weiss** of Dubois and King is doing the Rotary Club circuit giving talks on solar energy, according to the *White River Valley Herald*. It also stated that he received a master's degree in solar energy from Colorado U. . . . **David Hewitt** is Manager of Program Development for Computer Sciences Corp., Systems Group, in Falls Church, Va., and winner of the award for the longest job title around.

Robert Haworth married Nancy Robinson who is in her second year of medical school. He is a computer systems analyst at Kearney and Trecker in Milwaukee. Robert claims to have had a baby son on June 23, 1977, but I think it was really Nancy who had the boy. . . . **Larry Fisher** married Lori Bach in February, 1977. He is a pathology resident at the U. of Colorado Medical Center in Denver. He is working on his instrument rating after having recently obtained his pilot's license. Larry asks, "Where is Bruce Zweig ('71) living?"

I regret to announce that **Charles F. Wendler** died on July 2, 1977.



Ben Wilson's running again! In 1968 and 1969, Benjamin W. Wilson, '72, was an All-American runner in track and cross country, taking second in the steeplechase and fourth in the three-mile run at the 1969 N.C.A.A. national championships. Then he was sidelined by an injury. This spring Ben Wilson came back to Boston to prove that he's once again a great runner: he took 30th in a field of 4,674 entries in the Patriots' Day Marathon — 26.2 miles in 2 hours 19:34 minutes. (Photo: John W. Lepingwell, '80, from Technique*)*

Marked copy and check

I'm looking forward to hearing from the rest of you classmates. I've recently returned from a ski vacation in Steamboat Springs, Colo., and a rafting trip on the San Juan River in southwestern Utah. Somehow the Big Apple is not the same with its concrete canyons as the sandstone canyons of the Southwest. Drop a line and fill your classmates in on your news. — **Wendy Erb**, Assistant Secretary, 177 East 75th St., Apt. 21B, New York, N.Y. 10021

73

Welcome again, fans, this time to a rather sparse news month. Obviously everyone is getting ready for our reunion and saving the good stories to swap with hoary ol' schoolchums.

Doug Levene will be in Japan this summer, teaching at the Institute for International Studies and Training, before returning to this side to attend law school at Michigan. Eventually he would like to practice international law. His sojourn in Nippon means no reunion, but we wish him a happy trip nonetheless. . . . **Larry Esposito** received a Ph.D. from U. Mass in astronomy, and is now a research associate at the Laboratory for Atmospheric and Space Physics at Colorado. He is preparing models of the Venutian atmosphere's light scattering, to compare with upcoming data from N.A.S.A.'s Pioneer Venus orbiter. . . . **Daniel Knighton** received his M.D. at Harvard in 1976, and currently is in his second year of house staff training at Stanford Hospital in California.

Yours thespianically completed a run of 86 performances at the Charles Playhouse as El Gallo in *The Fantasticks* a trifle that I hope some classmates got over to see. Oh, I nearly forgot — Tony Scandora made it east as far as New York. Better luck next time, AES! — **Robert M. O. Sutton**, Secretary, 37 Fairbanks St., Brighton, Mass. 02135

74

Well, at last here is a Class of '74 column. I received a great letter from **Mike Kraft**, who is in California. He told me all about what he is doing — he is going to law school — and about some fellow classmates. The problem is that I put the letter in a special place and now can't find it. . . . **Patty Newbold** wrote me from Pittsburgh, Penn., where she is with her husband **Rod Gretlein** and working for CONSAD Research Corp., a Pittsburgh consulting firm. Patty now has a little boy named Alex, born August 1, 1977. Congratulations Patty!

Paul Schindler is a Public Information Officer for the Bank of America. . . . **Jim Gokhale** is doing fine working at Abt Associates, a Cambridge consulting firm. . . . **Lenny Guarente** is working toward a Ph.D. at Harvard. . . . **Bob Wake** recently got married and will be receiving a Ph.D. from Brown University. . . . **Mark D. Abkowitz** got married in the M.I.T. Chapel last August to Susan Bergstresser, a senior at Simmons College. . . . **Arnold Schiemann** wrote from Colombia, South America: "After being an independent consultant to several companies, I have set up my own firm. We have been quite successful. We are designing and implementing Data Base Systems. We have implemented a Spanish query language, already. We hope to go international in the near future." Arnold also tells us that **Carlos Pizano** is assistant to the President of Avianca, the international Colombian airline.

Robert Colopy has just received a master's in business administration from Stanford Graduate School of Business. . . . **Steven Glazer** is a member of the Washington, D.C., bar and working for the Office of Administrative Review of the U.S. Department of Energy. . . . **George Arzeno** is expecting his M.D. degree this May and will be interning in New York and Boston. . . . **Earl Waldin** is in a Ph.D. program in electrical engineering at Stanford University. . . . **William Young** is flying for the U.S. Air Force in West Germany. . . . **Jim Taul** is now living in Washington, D.C. . . . Congratulations to **Lionel Goulet** who got married last year to Rebecca Bergaer, and to **Aviva Weisel Eichler** and her husband David, '71, who have a son named Maor Nissan.

Mike Apted writes: "Now in my fourth year of the Ph.D. program here at U.C.L.A., Department of Earth and Space. My main course is experimental petrology on the origin of igneous rocks related to subduction zones and the igneous controls on associated global metallogenic provinces." . . . I saw **John Tierney** in a local Boston Bank, but since the event took place several months ago, I forget what was said. He must be doing fine as an actuary for Commercial Union Assurance. . . . And **Ray Van Houtte** writes that he is in *agronomy*, not astronomy. — **Dennis Dickstein**, Secretary, 17 Forest St., Cambridge, Mass. 02140

75

Many thanks to those of you who have contributed to the Alumni Fund, as you have provided me with all the news for this column!

Michael S. Cucchissi will be completing as of May his third year of law school at the University of Pennsylvania. He is currently Comment Editor of the *Law Review*. In September, 1978, he will begin a one-year clerkship with Chief Federal District Judge Samuel P. King in Honolulu, Hawaii. In October, 1979, he will begin work as an associate with Gibson, Dunn and Crutcher in Los Angeles, Calif. . . . **Christine Cowan** will be graduating from Harvard Business School in June and after a summer in Europe, she will be starting a full-time job with Westvaco, a paper company based in New York City. She will be located there for the first two years acting as an internal consultant. . . . **Bruce N. Davidson** began a graduate program in Public Health at U.C.L.A. last fall, specializing in international health.

Chris Dippel's latest activities include trying to start a University of Kansas crew, making whole wheat bagels, and keeping his wife in good humor with off-beat puns. . . . **Dave Katz** writes, "I should be finished with my master's in June. My adviser and I have been funded to continue analyzing the arctic meterology data I've been using for my thesis." . . . **Evan Schwartz** is still a med student at the University of Buffalo. . . . **Henry Heck** says, "After several moves, I am an epoxy resin salesman for Dow Chemical in San Francisco, My territory is from here to the Canadian border and includes some great ski slopes." . . . **Jeff Schweiger** is currently deployed with his squadron to Naval Air Facility, Kadena, Okinawa, Japan. He's serving both as flight crew and as Assistant Air Intelligence/Photo Officer. His squadron is scheduled to return to Moffett Field in early June.

Keep those cards and letters coming! — **Jennifer Gordon**, Secretary, 22 Centre St., Apt. 9, Cambridge, Mass. 02139

76

The mails have yielded their bounty. **Peter Kaufman** is now a second-year med student at George Washington University in D.C. He writes that he "worked at the N.I.H. doing neuromuscular research. Among the diseases I was working with were Dvohenne's Muscular Dystrophy, malignant hyperthermia, Amyo tropic lateral sclerosis, myesthenia gravis, and others." He still misses Boston very much. . . . **Reynold Lewke** writes that he has married Laura Virginia Baker, Wellesley, '77, on July 23, 1977 in Chappaqua, N.Y. Both are students at McGill University Law School in Montreal. Reynold is in his second year and is the current class president. Congrats! . . . I have another note from **Lee Gearhart**, who writes that "to support myself in grad school, I steal sugar packets from restaurants, re-package them, and sell them on the black market to third-world nations. I also deal in used silverware and fraudulent Olde English folkdance recordings." . . . **Bob Quirk** has sent along some disturbing news. "I was involved in a car accident in October in which I did some creative rearranging of my internal organs — the doctors didn't approve and put them back where they were before. I spent a couple of months in the hospital and will be returning to work soon." I hope Bob has completely recovered. My apologies for the delay in reporting the news.

While wandering around, I picked up some news of classmates. **Lissa Martinez** is working for the Federal Maritime Administration in D.C. Apparently, they will send her to grad school. . . . **Bob Chen** has been working for the Federal Aviation Administration in D.C. and currently is at the Institute's Meteorology and Technology Policy Program. . . . **Irene Chan** will be finished with an M.S. in chemical engineering from M.I.T. when these notes are printed.

This summer, do not be lazy — write. I need some news. — **Arthur J. Carp**, Secretary, 67 Badger Cir., Milton, Mass. 02186

77

We have a fair amount of news this issue due mainly to the efforts of **Carol Catalano**. Our newly appointed Class Agent organized the end of the April Class of '77 Telethon. Her crew managed to contact about 55 people during the evening with a 45 per cent pledge rate. Not a bad night all in all.

Jeff Starr is keeping himself busy teaching at Glenbrook North High School while studying for his M.A.T. at Northwestern. In his free time he heads out with the Chicago Rocks and Minerals Club to various sites in the area. . . . **Paul Ackman** says, "Hello everyone!" from U.C. at San Diego. He's out there in grad school on a Regent's Fellowship in the department of physics. . . . Hang-gliding and cross-country skiing have been occupying **Mark Anderson**'s spare moments these days. He's working up in Dearborn for Ford as a process engineer in their engine plant.

John Monaco is at that West Coast country club in Palo Alto in the medical microbiology program. He wrote to say that the flooding during the winter was enjoyable. I'm sure it's tennis weather by now and getting pretty hard to keep working indoors. . . . **Bill Brown** is at Duke Law School and writes, "It's great to be back in the South!" . . . **Manuel Lowenhaupt** is at Harvard Medical School and had an interesting January break. He worked in Woodstock, Vt., for a physician to get some exposure to the problems of practicing in a rural area. . . . **Steve Gaskin** wrote to indicate that one shouldn't believe all those glamorous navy ads. "I am now attending Surface Warfare Officer's School and it has all the excitement, challenge, and romance of junior high school. Well, maybe not the romance." The saving grace is that it's in Newport, R.I., so he comes up to Boston occasionally to bum around.

A long letter from **Debbie Stutman** filled with information about people was a pleasant surprise. She is a chemical engineer turned astronomer at Penn State University. Having passed her Ph.D. qualifiers, she'll be working at the Kit Peak National Observatory in Tucson, Ariz. "It's so amazing when someone is willing to pay you for something you'd almost do for nothing!" . . . **Marita Gargiulo** is at Case Western in Cleveland in the nutrition program and should finish her master's degree in August. . . . **Werner Haag** is at U.T. in Knoxville, Tenn., studying environmental chemistry, pollution and the like.

Loren Shure is at Scripps Institute of Oceanography in San Diego heading for a Ph.D. in geophysics and "doing all sorts of outdoor stuff — swimming and horseback riding as well as occasional studying." . . . Soon to be found swooping down out of the heavens is **Robert Crossan**. He's at the Kingsville, Texas, Naval Air Station in their jet training program to be completed in December.

David Beyer left a year early from the Institute to go to med school at the University of Arizona. He'll be finishing up his second year at the end of July. Debbie finished up her letter saying, "I like to know where people are. Who knows when you'll be passing through someone's new hometown?" Who knows indeed! I'll still welcome as much information that is sent my way and get it into the class notes. — **Doug McLeod**, Secretary, 11 Silvey Pl., #1, Somerville, Mass. 02143

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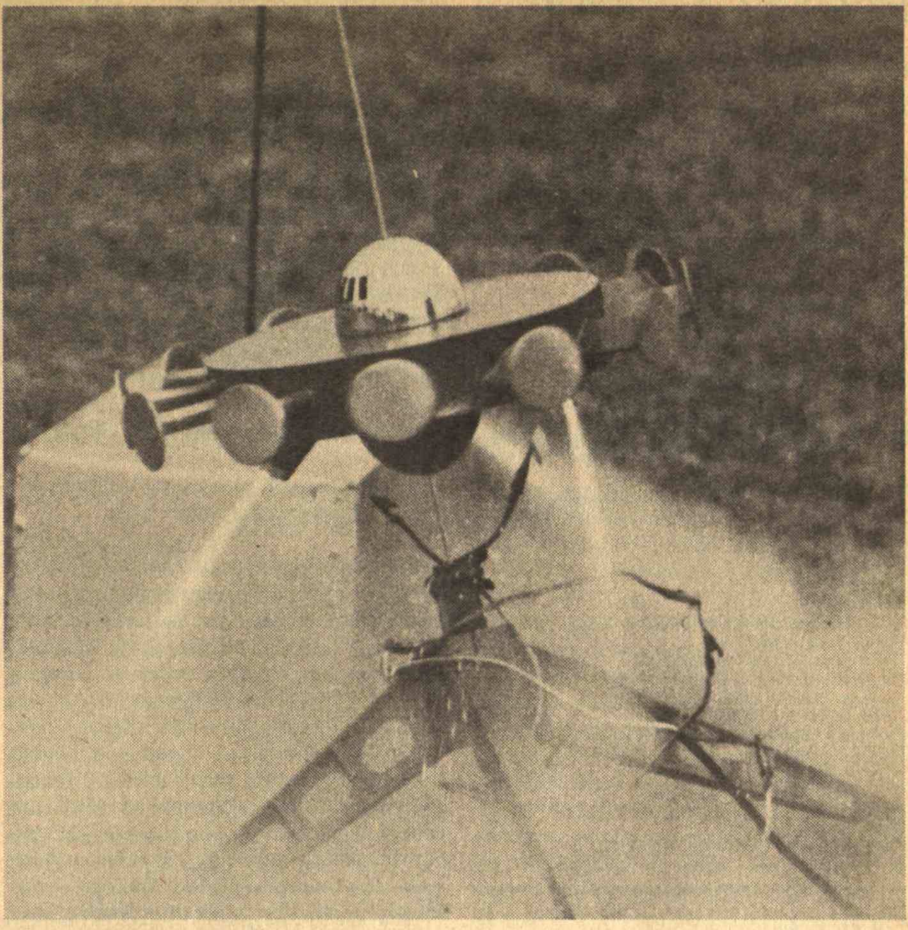


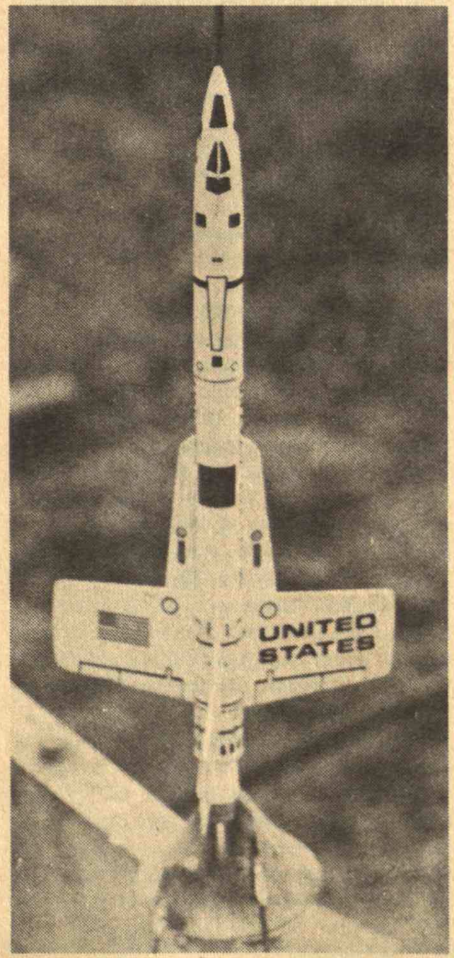
M.I.T. Model Rocket Convention: Height, Control, Stability, and Nested Raw Eggs

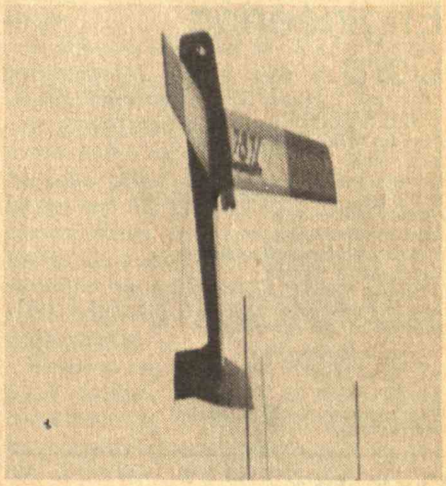
The privilege of firing rockets is not reserved to N.A.S.A. and the U.S.A.F. Many "ordinary" people have also done it for the last 20 years and more. No matter that their rockets are rarely bigger than six feet long — it's still a rewarding and even compelling pastime whose devotees share at least two basic qualities: good legs and perseverance. The first are essential when the wind plays with the rocket's recovery parachute and a landing occurs a mile or more away from the launching site; the second, when the recovery parachute fails to open for some obscure reason; then it's time for a new rocket.

Model rocketry began in the U.S. in the 1950s, at the dawn of the space age. Even as the U.S. Army was testing rockets to launch its first satellite, many young people were building and launching their own rockets. It was a dangerous hobby in the beginning: one person out of seven was killed or injured while manipulating propellants and explosives to fuel those early engines. Then, in 1955, Orville Carlisle, a Nebraska shoe salesman, invented a model rocket engine that could be safely used by everybody, and ever since then model rocketry has been safe — and growing. Today the largest makers of model rocket engines claim that 6 million launches take place each year in the U.S. The National Association of Rocketry has 2,500 active members, and there are at least 40 times that many model rocketeers who are unaffiliated.

Some buy model rocket kits, in a great choice of models suited to many skills and budgets. There are simple beginners' models costing a few dollars and taking a half hour to assemble, scale flying models which are faithful copies of N.A.S.A.'s famous launches, and — for those who want to leave N.A.S.A. behind, crushed with jealousy — it is easy to enter the world of science fiction with models of Star Treks, Star Ships, and the famous X-wing fighter.

Purists of model rocketry, however, are scornful of such short-cuts to success. Their kicks come from designing and building their own rockets. Kent Garton, for example, ten years old, has already designed and





A model of a U.F.O. spinning like a frisbee 10 feet above the ground (above) showed the not-so-serious side of model rocketry at the M.I.T. Model Rocket Convention early in April. The very serious side was represented by the 4.3-ounce radio-guided rocket shown on its launch pad (left). Sixty models, some of which will be entered in the world championships at Yambol, Bulgaria, late this summer, were flown on Briggs Field at M.I.T., where the student Rocket Society enjoys a top reputation for research and its members a dominant place in national competitions. (Photos: [illegible] '73)

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built 40 model rockets. And each month, with his allowance of $12, he says, he builds four more. Kent came with his father from the West Coast for the 1978 M.I.T. Model Rocket Convention the first weekend of April. It's a technically-oriented annual gathering of the model rocket hobby which brought 40 people to Cambridge for sessions on all the decisions a model-maker has to make: size, proportions, and weight — the lighter a model is, the higher it flies for a given size of engine and charge of fuel; aerodynamics, engines, and recovery systems. After a day at the convention it was clear that model rocketeers who design, build, and fly their rockets learn a lot about physics, aerodynamics, mathematics, electrical systems, and even construction.

Flying Saucers, Cinerocs, and a Snow Man: Champions Are Made Here

The payoff came in the competitions, when 60 model rockets of every description were flown from Briggs Field — baby rockets, two-stage rockets, gliders, flying saucers, giant rockets, cinerocs (rockets carrying cameras), even an aerodynamic styrofoam snow man flown as an April Fool's Day joke. Competitive flights are judged — of course — on height, control, and stability. All these, and some other attributes as well, are wrapped up in the egglofting contest: the highest altitude attained by a rocket in which a raw egg has been nested. The egg — obviously — must be intact after landing, and great designing skills are necessary to prevent an omelet and win the contest. The model rocket must be built of impact-resistant materials and fitted with an automatic parachute to ensure a soft landing. And all this must be accomplished with a rocket which weighs much less than one pound — engine and precious cargo included.

Top-notch technical skills pay off in such competitions, and the M.I.T. Rocket Society is a maker of champions. In 1972 and 1974 the teams chosen by the National Association of Rocketry to represent the U.S. in the World Rocket Championships each included one member of the M.I.T. community; but in September, 1978, six of the nine U.S. rocket champions travelling to Yambol, Bulgaria, will come from the Institute. This near-sweep of the team is a breakthrough for model rocketry at the Institute, says Robert W. Parks, '78. With him on the trip will be Geoffrey Landis, '78, John Langford, '79, Harold Youngren, '78, Bernard A. Biales, '66 (a member of the scientific staff at Beth Israel Hospital, Boston), and Christopher C. Flanigan, '75, of General Dynamics Corp., San Diego.

Messrs. Langford and Flanigan will compete with a 1/15th scale model of the Athena H rocket which weighs less than 500 grams, while Messrs. Landis, Youngren, and Biales will fly a "boost glider" — a rocket with wings which glides to its landing instead of depending on a parachute recovery system. Mr. Youngren already holds two world records in different categories of "boost gliders," and Mr. Flanigan has one.

The third event in Yambol remains a mystery. The M.I.T. team hopes for a contest among radio-guided "boost gliders" — craft designed to rocket upwards and then be guided down to a safe landing near a designated target. Mr. Parks is the designer of such a glider, made of paper and balsa wood, that weighs 120 grams (4.3 ounces) including both radio and engine. Some who saw it at the M.I.T. convention in April venture that this may be the lightest glider model in the world. — Odile Olsen

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Henry Ford II Scholarships

Two grants of $100,000 each from Ford Motor Co. have been added to M.I.T. endowment funds; income from them will provide scholarships to students with outstanding academic records in the Schools of Engineering and of Management. It's part of a $2 million program to provide Henry Ford II Scholarships at 12 American and four European universities.

A Football Team for M.I.T.?

Once more this spring a group of avid would-be football players renewed the sporadic effort to add their sport to the roster of intercollegiate athletics at M.I.T.

Undergraduates led by James J. Dunlay, '79, lined up equipment, a coach, and a tentative schedule for the fall; but approval to launch a club remained elusive.

Equipment was available from the Rochester Institute of Technology, where a football team was disbanded last year. Opponents would include Brooklyn College, Fitchburg State College (where an opener could be scheduled for September 22), and Duquesne College.

But the "club" needed three crucial things to move ahead:

☐ Sanction from the M.I.T. Athletic Association and Athletic Board.

☐ A loan from the Finance Board to pay for the equipment available in Rochester.

☐ Space on Briggs Field for fall practices, which — given M.I.T.'s crowded athletic facilities — may be the most elusive of all.

First Choice for N.S.F. Fellows

More than 4,000 students from throughout the U.S. who graduated this spring applied to the National Science Foundation for fellowships for graduate study. N.S.F. picked 490 of them as Fellows, to receive stipends of $3,900 and education allowances of $3,400.

When the dust settled, M.I.T. discovered that 32 of the new Fellows were completing undergraduate study at the Institute — more than at any other institution. And a total of 55 of the new Fellows — including seven now at M.I.T. — will bring their N.S.F. Fellowships to the Institute next fall.

The Undergraduate Association's General Assembly met for the first time in 1977-78 this spring, called together by Barry A. Newman, '80, (right) just a week after his victory in the all-campus elections for President of the U.A. "The only way for student government to work is to act as a communications network for students and their various representatives," he said in his ~~pre-election statement~~ in The Tech. *(Photo: John M. Grunsfeld, '80, from* The Tech*)*

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Government = Communication

Communication is the name of the game, says Barry A. Newman, '80, the new President of the Undergraduate Association.

Mr. Newman ran for election this spring on a platform emphasizing the U.A.'s role as communicator, and he intends to follow through. "We're looking to get people to communicate," he told his new General Assembly at its first meeting.

By this he means that students should talk more among themselves — and especially that they should talk more with the M.I.T. administration. He hopes this will help students approach the administration with the basic premise that "they're not out to screw the students."

Accordingly, Mr. Newman has transformed a bulletin board in the lobby of Building 7 into an Institute calendar, on which are shown the week's social events, student activities, and meetings of all Institute committees; "getting information out to the students should be the main function," he says. And he'll use the Undergraduate Association's social budget for "small events that can mix faculty and students," he promised his new General Assembly at the group's only meeting of the year.

"Scientists in Particular Hate to Write"

Writing about science is hard. And "scientists in particular hate to write," says Stephen Gould, Professor of Geology at Harvard. The result: a dearth of lively and informative science writing.

M.I.T. Professors ~~James Paradis~~ and ~~Rae Goodell~~ of the Humanities Department ~~agree.~~ Two new science writing courses offered next fall stem from the need for better writers with a background in science.

"The Scientific Essay: Tradition and Practice" is "a course with a historical emphasis, intended for students who would like to improve their writing skills and to explore the evolution of technical expression from the Renaissance to the modern era," explains Professor Paradis. Students will examine "the style and purpose of selected essays by early and modern scientists such as Bacon, Harvey, Faraday, Agassiz, Darwin, Einstein and others. Consideration will be given to the cultural image of the scien-

Student Elections: Changing Moods

By William Lasser, '78

Politics as usual has ~~been born again~~ at M.I.T., with the election of an Undergraduate Association President who was described as "the most experienced and polished candidate in the race."

This year's undergraduate election stands in striking contrast to last year's election of Peter Berke, '78, a candidate in the Jimmy Carter mold who eschewed issues and instead pledged a better way of life for M.I.T. students.

In an apparent reaction to Berke's nonpresidential style, undergraduates this year chose Barry Newman, '79, as U.A.P. from an unusually large field of six candidates in a hotly contested contest. Turnout this year surpassed 36 per cent of the registered students, an increase of eight percentage points from 1977.

Newman, running with vice presidential candidate Tim Morgenthaler, '80, waged a meat and potatoes campaign which pledged communication between students and faculty and which stressed the student government experience of the ticket. They promised old-fashioned political organization: "we hope to develop a working corps of students capable of responsibly representing student concerns and organizing student efforts."

This is all very different from the recent past. Two springs ago, the presidency was won by Phil Moore, '77, a well-known student activist in an age of apathy. Moore's conception of student government harkened back to the late 1960s, including a view that "the U.A. and its officers should be something all students can unite with and tell the administration — forcefully — what we do want and what we *won't* accept."

In 1977, Berke ran on a ticket which called for "places to sit down," "lots of trees," "a comfortable Lobby 7," "a permanent bar/club/disco" and "lower pressure." The leader of a disco dance class, one of the most popular activities on campus, Berke wrote a poem in his campaign statement which ended "Just shake it to the beat." He was elected. [illegible] appeal was to many a refreshing change from the heavy-handedness of so many U.A.P. candidates. His "anti-Washington" pitch, as it were, and his almost Populist approach swept him to victory after four ballots. In the end, Berke found fighting the establishment as difficult as Carter is finding it, and he leaves office with most of his goals unrealized.

Throughout last year, when I was editor of *The Tech*, Peter Berke and I had several differences of opinion, although I came in the end to at least respect his attempt to shun the affectations of power and attempt to work within his particular style. But the student body, apparently looking at results, decided it needed a more conventional leader.

In selecting Newman as U.A.P., the undergraduates passed over a candidate whose slogan was "vote issues," and several candidates who emphasized social events and a vague commitment to making the voice of the student body heard by the faculty and the administration. When push came to shove, the winner was not a Jimmy Carter, but a Jerry Ford: experienced, well-versed in the subtleties of student government, promising progress through conventional politics.

Students are convinced that the democratic process can work at M.I.T. They overwhelmingly ratified resolutions calling for increased student participation on faculty committees, and for more openness in the conduction of faculty business. By smaller but still tremendous majorities, they asked the faculty to reject the recent grading report, and gave approval to a referendum system for resolving student-faculty policy. None of these votes has any practical effect, but they do demonstrate where students stand on what they see as the key issues affecting them.

If American politics tends to move in slow, long-term cycles, M.I.T. politics varies unpredictably from year to year. Though fluid in nature, student election returns do much more than just elect candidates — they offer an important insight into the state of the campus.

tist, varieties and conventions of scientific essays; effects of specialization on length, style, and vocabulary; variant language systems; technical obsolescence vs. literary permanence; the scientist as critic."

"Advanced Science Writing," the other new course, will require each student to write a feature article (6,000 to 8,000 words) on a scientific issue or development for publication in a magazine or newspaper that circulates to a lay audience. "Works by contemporary science writers will be discussed, as will topics important to in-depth reporting on science: public attitudes toward science, the role of the expert in democratic society, mechanisms for the handling of scientific controversy, the relationship between science and media, ethical issues in investigative writing, and the quality of press coverage of science," explains Professor Goodell.

She taught two science writing courses this past year: an introduction to writing for the general public on topics in science, engineering, medicine, and environment (she invited guest lecturers from newspapers, magazines, book publishing, radio, television, film and industry and university public relations), and a science writing internship. Students interested were given part-time internships in the Boston area media (and some wrote science pieces for *Technology Review*).

Professors Gould, Goodell, and Frank Bello, Associate Editor of *Scientific American*, participated in a symposium on science writing and the teaching of science writing at Harvard last winter. They discussed the pitfalls and problems of science writing — and how to teach students to avoid them.

Some of their observations:

"Science writing should possess the qualities that make writing vivid in any field: the use of metaphor, direct statement in short sentences, a prudent use of technical terms," Rae Goodell told the group. Special terminology is superfluous — technical material can be explained well enough without it. "You don't lose any accuracy by leaving out the technical term," she emphasized.

Professor Goodell identifies three areas of science writing: writing directed to the public (which relies ever more heavily on scientists for both information and opinions); "scientific writing," the discourse used among professional colleagues; and "technical writing" that merges the two and can overlap either.

She feels there is a trend toward improving the teaching of science writing, and the tendency is to choose one of two approaches: "giving science students more training in writing technical reports and journal articles, and giving journalism students more complete science training." She prefers programs that unite the two aims.

Professor Gould offered a reason for dull writing about science: it is produced according to a rigid formula which determines its structure (1. abstract, 2. introduction, 3. materials and methods, 4. results, 5. discussion). Its proper style, he says, is thought to be impersonal, formal, and hieratic. The view is that "science is a special activity . . . that science has a rigid method, independent of culture and time. Indeed, if you can show that scientific work is influenced by the surrounding culture, it only proves that the scientist is doing the wrong thing." Then science is "a heartless activity . . . It marches inexorably towards truth by the accumulation of factual information . . . theories replace theories when old theories collapse under the sheer weight of the gathering of that information by the scientific method . . . science when it's done well is independent of culture, independent of passion . . . Of course, science has to be done by people . . . but there's nothing particular about the personality or the training of the man who does science that needs to be impressed upon the scientific work . . . Science in its purest form is an activity apart from the person who does it."

Professor Gould disagrees with this set of beliefs. He says they "virtually guarantee bad writing." The reader's curiosity is turned off by the pre-ordained structure. But, says Professor Gould, the dull and pompous style endures because of the "utility of the myth of the scientific priesthood": the style seems to give prestige to science in general and to the findings of the scientist.

There are pressures to conform to the style, too. When faced with "selling" their research in the form of proposals, scientists tend to fall into the approved oracular mode. "Finally, the impersonal style conceals whatever feelings of inadequacy the scientist as a writer may have."

Good science writing, says Professor Gould, is like good detective fiction. It "admits the reader into the process of discovery, which is likely to be tentative, personal, and — when it all comes together finally — exciting." He feels that writers that are just beginning need to practice learning to "think well" — they should not try to mystify. Structure and style should depend not on a formula but on what facts, ideas and values matter most.

Professor Goodell and Professor Bello both agree that science writers should develop a clear sense of the audience they address. "Never underestimate the audience's intelligence, never overestimate their knowledge," Professor Goodell teaches her students. — *M.L.*

I
Civil Engineering

Moderator at two discussions held by the National Symposium on Technology was **George Bugliarello,** Sc.D. '59, president of the Polytechnic Institute of New York. The subjects were "Technology and Free Enterprise" and "Technology and People." ... **Polyvios C. Vintiades,** S.M. '61, has been elected a vice president of Arthur D. Little, Inc. He joined the company in 1961 at the Cambridge headquarters. After a period in Brussels as managing director, Mr. Vintiades was named head of the Middle East Regional Office with its principal offices in Athens, Greece ... **Robert F. Seedlock,** S.M. '40, a retired major general with nearly 40 years in planning, designing, construction and management of bridges, inland waterways, highways, including the Burma Road, and airports, most recently the new Jeddah airport, has received honorary membership in the American Society of Civil Engineers, the society's highest award.

II
Mechanical Engineering

Dwight E. Beach, Jr., S.M. '65, has been named president of American Aero, Inc. The company manufactures hydraulic cranes and high-pressure cleaning units for the petroleum industry ... **David Van Ostrom,** S.M. '60, a senior staff engineer with the A.C. Sparkplug Division of General Motors, has been elected to the Board of Trustees of John Wesley College in Owosso, Michigan.

III
Materials Science

Robert L. Coble, Sc.D. '55, Professor of Ceramics at M.I.T. has been elected to membership in the National Academy of Engineering for "contributions to the theory of sintering of materials and to ceramic processing." Election to the academy is considered among the highest professional distinctions that can be conferred on an engineer ... **Gregory B. Stephenson,** a graduate student, has won a Hertz Foundation Fellowship. The fellowship includes tuition, medical fees and a stipend ... **Nicholas J. Grant,** Sc.D. '44, Abex Professor for Advanced Materials, has been awarded a grant from the Jacob Wallenberg Foundation through the Royal Swedish Academy of Engineering Sciences, to be used in studies on alloys produced from rapidly quenched particulates.

George A. Parks, Ph.D. '60, a Stanford faculty member since 1959 with joint appointments in the Department of Geology and Civil Engineering, has been appointed to the endowed Alice and Donald M. Steel professorship in earth sciences. His research interests include the impact of pollution on natural aquatic systems and he has been instrumental in the organization and development of the Department of Applied Earth Sciences ... **Jack H. Vernon,** S.M. '54, has been elected a vice president and appointed manager of the Boston office of Heidrick and Struggles, an international management firm. Mr. Vernon joined the firm in 1975 ... **Frederick S. Blackall IV,** S.M. '75, has been appointed technical director of Taft-Peirce Mfg. Co., where his duties will involve product planning and technical consulting. He was formerly with Rheocast Corp. in charge of equipment design and metal production. Rheocasting, a new process that permits the die casting of high-temperature alloys like steel and brass, was the subject of his thesis at M.I.T.

IV
Architecture

Marvin Goody, M.Ar. '51, of the architectural firm Goody, Clancy and Associates is working on the first part of plans for what the *Boston Globe* calls "an exciting concept" in downtown Boston. The object is the new State Transportation Building, a multimillion dollar construction. Goody is quoted predicting that "this building is really going to change the face of the theater district." The ground floor of the eight-story structure will be filled with commercial activity, and, Goody hopes, connect to the lobby of the Saxon Theater, which may be the new home for the Boston Opera Company. The interior space will be an atrium with government offices above surrounding the floor-to-ceiling open space — workers can look down on the mall activity below. The project will get under way two years from now, providing the city can cut the red tap and deliver the site in time.

John W. Peirce, M.Arch. '47, Architect, was honored by the Massachusetts Conservation Council at its 1977 Environmental Awards dinner last winter as one of the State's outstanding conservationists. He was cited for establishing the Essex County Greenbelt Association, the state's first regional conservation trust, in 1961. He is currently President of that Association which is credited with preserving more than 1,249 acres.

Masaaki Sakuta, '60, is Professor in the Department of Architecture, Nihon University, Tokyo, Japan. ... **Luis Unikel,** M.C.P. '58, became Director of the Center for Economic and Demographic Studies of El Colegio de Mexico in January, 1977.

V
Chemistry

Ellen R. Bressel, Ph.D. '60, has been appointed vice president for Applied Technology at Avco Everett Research Laboratory. In her new position, Dr. Bressel will conduct studies on laser and reentry physics; she will also direct the laboratory

Congratulations from Alfred A. H. Keil (left), former Dean of the School of Engineering, to two new Henry L. Doherty Professors. The Doherty Professorships, are the result of a grant to the M.I.T. Sea Grant Program; the Henry L. and Grace Doherty Charitable Foundation, Inc., wanted to encourage younger faculty to work on ocean science and ocean resources. Alician V. Quinlan, '68, Assistant Professor of Mechanical Engineering, will study the ocean algal blooms which annually foul sections of New England coastline; and Francis Noblesse (center), Assistant Professor of Ocean Engineering, will continue work on ship wave resistance calculations

toward new technological development. Prior to joining A.E.R.L. in 1966, Dr. Bressel was a staff member of M.I.T.'s Lincoln Laboratory, where she participated in reentry vehicle signature studies taking place on Kwajalein Island in the South Pacific . . . **Charles A. Christy,** Ph.D. '65, moves from being a senior staff member at the parent company to becoming regional manager of the New England office of Arthur D. Little Systems, Inc. The subsidiary company develops and installs complete "turnkey" minicomputer systems throughout the country. . . . Two M.I.T. alumni, both of the Pfizer Co., have been selected to contribute to the fourth edition of the "bible" of drug research texts, *Burger's Medicinal Chemistry*. **Gerald F. Holland,** Ph.D. '56, has been with Pfizer since 1958. His research has been directed at drugs to control metabolic disease and central nervous system disorders and recently at antihyperlipidemic agents which control levels of cholesterol in the bloodstream. **George M. Milne,** Ph.D. '69, has focused his research toward the treatment of pain.

David W. Ellis, Ph.D. '62, will become president of Lafayette College in August this year. Dr. Ellis began his academic career as an assistant professor of chemistry at the University of New Hampshire and is currently vice president for academic affairs there. He has taken part in many community and professional activities, including the chairmanship of accreditation teams for the New England Association of Schools and Colleges. Lafayette College informs us that their Search Committee, consisting of faculty, students, alumni and trustees, gave their enthusiastic endorsement to Dr. Ellis after having reviewed more than 400 candidates. Dr. Ellis follows in the footsteps of his father, Dr. Calvert Ellis, who was president of Juniata College for 25 years . . . **William D. Phillips,** Ph.D. '51, currently assistant director of research and development at Du Pont, has been appointed chairman of the Chemistry Department at Washington University. He has served in various capacities at Du Pont since joining them in 1951, among others as technical director of a joint venture with a British firm on the microbiological conversion of carbohydrates to protein for use as human food. Dr. Phillips is on the advisory committees of several universities and professional journals.

VI

Electrical Engineering

Glendon P. Marston, Sc.D. '71, named a vice president of the Institute For Advanced Professional Studies of Newton, Mass, where he will design training programs for microprocessor applications. The microprocessor is said to be on the verge of improving the performance of many consumer products as well as manufacturing facilities and information flow in offices . . . **Edwin R. Hiller,** E.E. '56, of the Raytheon Co., has been named a consulting engineer in the company's Missile Systems Division. He has been with Raytheon since 1969 and specializes in radar system development . . . Another Raytheon man, **Alfred J. Appelbaum,** S.M. '58, is one in a group of three engineers who have devised an electronically steered communications system that enhances the capabilities of phased array radars to identify military aircraft. Mr. Appelbaum is a principal engineer in the antenna and microwave systems department and holds one patent.

I.E.E.E. Press announces its recently published *Systems Engineering: Methodology and Applications* edited by **Andrew P. Sage,** S.M. '56, Acting Chairman and Associate Dean at the University of Virginia. The book deals with the role of technology in modeling, planning for, and addressing social problems . . . **Elias P. Gyftopoulos,** Sc.D. '58, Ford Professor of Engineering at M.I.T., is the co-author of an article published in the March/April issue of *Harvard Business Review*. The article, titled "Capital Investment to Save Energy," explores energy conservation possibilities . . . Technology Transfer, Inc. sent us a brochure on their communication seminars this summer. Two of the instructors are: **Leonard Kleinrock,** Ph.D. '59, Professor of Computer Science at the University of California, a well known lecturer in the field of queueing systems and their application, and the author of three books on computer networks; and **Lawrence G. Roberts,** Ph.D. '59, President of Telenet Communications Corp. and the author of several papers on data communications.

Long-time Arlington, Mass., resident, **Harold H. Seward,** S.M. '54, has filed nomination papers for a two-year vacancy position on the Board of Selectmen. Mr. Seward is an inventor-entrepreneur and holds several patents. He says his most satisfying achievement came in 1955 when he invented the guidance computer used on board the Polaris missile . . . **James Milton Ham,** Sc.D. '47, has been appointed President of the University of Toronto, Canada's largest university. Professor Ham has been with the university for 25 years, most recently as Dean of the School of Graduate Studies. He has helped establish the new Institute for the History and Philosophy of Science and Technology, and he has been a visiting scientist to the U.S.S.R. and to Cambridge University. During 1974-1976 he served as chairman of the Ontario Royal Commission on the Health and Safety of Workers in Mines . . . The Hertz Foundation has announced the winners of the 1978-79 fellowships. Among them: **Daniel U. Friedman** and **Guy L. Steele, Jr.,** currently enrolled in this course . . . **Nolan T. Jones,** S.M. '54, dropped a note to inform us that he is on a N.A.T.O. assignment and living in Brussels, Belgium.

David D. Holmes, S.M. '50, is Director of the Television Research Laboratory, R.C.A. Labs, Princeton, N.J. . . . **James G. Nelson,** S.M. '54, is Director of Systems Engineering for the Vought Corp., Dallas, Tex . . . **Eric S. Backjord,** S.M. '56, is Director of the Division of Nuclear Power Development, U.S. Department of Energy . . . **Marco Bucciarelli,** S.M. '68, is a senior research scientist with the American Institute for Research. . . . **Daniel U. Wilde,** Ph.D. '66, reports that he has been elected to the Board of Trustees of Engineering Index, Inc., the "world's foremost producer of a computerized data base of transdisciplinary engineering information." . . . At Caltech, **Ivan Sutherland,** Ph.D. '63, has been appointed to fill the Fletcher Jones Chair in Computer Science, in the Division of Engineering and Applied Science.

VI-A

Cooperative Program in Electrical Engineering and Computer Science

VI-A's Annual Business Dinner and Open House was held at M.I.T. on March 6. Over 300 faculty, company representatives and students attended the Open House held this year in the Sala de Puerto Rico of the Stratton Student Center. During the following two days the companies conducted a total of 739 interviews from amongst the 141 students who applied for admission to the Program's VI-A Class of 1978. The participating companies made available 86 positions for this new VI-A Class. Final admissions will be firmed up by the end of the third week in April, according to Director Tucker.

Currently 12.6 per cent of the students enrolled in the Electrical Engineering and Computer Science Department (undergrads plus grads) are in the VI-A Program. This year 55 per cent of the sophomores in Course VI applied for admission to VI-A.

Director **John A. Tucker** was asked to serve for his third year on the Scholarship Selection Committee for the Andover and Waltham Divisions of the Hewlett-Packard Co. Eighteen sons and daughters of employees were interviewed as part of H-P's program of awarding scholarships from a company-wide employee contributory plan.

William R. Bidermann, '76, has started his employment with the Corporate Research Labs. of the Hewlett-Packard Co. in Palo Alto, Calif.

Dr. **Stephen P. Denker,** '59, has returned to

M.I.T. as Director of the Alumni Fund. This appointment was recently announced by Messrs. James A. Champy, Executive Vice President of the M.I.T. Alumni Association, and Thomas H. Farquhar, Chairman of the Alumni Fund Board. Steve did his VI-A work with the General Radio Co. (now named GenRad) receiving the S.B. and S.M. degrees in 1960 and the Ph.D. in 1963. We are happy to welcome him back to the campus!

Recently honored by the Institute of Electrical and Electronics Engineers, Inc. (I.E.E.E.) was Professor **Frederic R. Morgenthaler**, '55. Professor Morgenthaler was awarded their highest grade of membership, that of Fellow of the Institute. Professor Morgenthaler did his VI-A work at Bell Laboratories and is currently the Lab's VI-A Faculty Adviser.

Jeannette M. Wing, '78, is currently serving as President of M.I.T.'s Massachusetts Beta Chapter of the Tau Beta Pi Association — a national engineering honor society. Jeannette will be pursuing her two VI-A graduate work assignments at Bell Labs this summer and fall.

We are happy to announce that Professor **Joseph Weizenbaum** will be the new VI-A Faculty Adviser to the I.B.M.'s Endicott and Yorktown Heights, N.Y., facilities. — **John A. Tucker**, Director, VI-A Office, Room 38-473, M.I.T., Cambridge.

VII

Life Sciences

Julia C. Sullivan, M.P.H. '42, has retired from her position as Senior Research Assistant in Pediatrics at Case Western Reserve Medical School and moved back to Massachusetts. She writes that she may return to part-time work after she has settled down in her new home . . . **Simon Silver**, Ph.D. '62, Professor of Biology, Microbiology and Immunology at Washington University, has been appointed editor-in-chief of the *Journal of Bacteriology* . . . **Lillian Derderian**, M.P.H. '44, has been appointed Dean of Students at North Shore Community College. She has worked in the student services area of the college since 1966, one year after the school was founded. In addition to her academic posts, she has served as acting chief of the Bureau of Health Information at the Massachusetts Department of Public Health . . . **Paul R. Gross**, former faculty member at M.I.T. and currently Graduate Dean and Professor of Biology at the University of Rochester, has been named President and Director of Woods Hole Marine Biological Laboratory. Dr. Gross is best known for his contributions to our understanding of how the genes control the development of an individual.

Grant Fairbanks, Ph.D. '69, has been appointed to the rank of senior scientist at the Worcester Foundation for Experimental Biology, Shrewsbury, Mass. He is a specialist in cell membrane biology, and is studying the red blood cell membrane and its defective functions in sickle-cell anemia and other blood diseases. . . . Dr. **Linda M. Hall**, assistant professor in the M.I.T. Department of Biology, has been named as one of the first recipients of the McKnight Scholars Awards in Neuroscience. The awards are given to stimulate research in neuroscience, and are in the amount of $25,000 per annum for a three-year period.

X

Chemical Engineering

John P. Snyder, S.M. '49, senior staff engineer with CIBA-GEIGY Corp., spent hundreds of spare time hours over the last nine months to develop a series of 82 equations to solve a space-age map projection problem that government, university and industry experts had been unable to crack. For this he recently received the John Wesley Powell Award, and now he plans to move on to a new project with applications to the Space Shuttle . . . The National Academy of Engineering has elected new members. Among them are: **James Wei**, Sc.D. '54, Warren K. Lewis Professor of Chemical Engineering and head of the department at M.I.T., "for the advancement of chemical engineering by mathematical analysis of complex reaction and applications to commercial processes"; and **David Brown**, S.M. '40, executive vice president of Halcon International, for his "contributions to petro-chemical processing technology, engineering literature, and engineering education." The Academy also announced the election of **Frederic A. L. Holloway**, Sc.D. '39, vice president of Exxon Corp., as treasurer.

Byron Hill, S.M. '61, has been promoted to staff engineer at Union Carbide . . . **Robert W. King**, S.M. '42, also with Union Carbide, has been appointed President of the newly formed Medical Products Division . . . News from **Giles R. Cokelet**, Sc.D. '63, reached us via his father-in-law. Dr. Cokelet and his family are moving to Rochester, N.Y., where he has accepted a professorship in medicine and a courtesy appointment in the School of Engineering . . . **Richard T. Traskos**, Sc.D. '66, senior research engineer at Rogers Corp., Conn., was a speaker at the recent Electrical/Electronic Insulation Conference in Chicago. He presented his paper on "Flexible Circuit Composite Based on a Fiber Blend."

XI

Urban Studies and Planning

Francis T. Ventre, Ph.D. '73, has been appointed chief of the Environmental Design Research Division of the National Bureau of Standards' Center for Building Technology. Dr. Ventre has served as a consultant to public agencies and private firms; he has also taught at U.C.L.A. and M.I.T. In 1968, he co-founded *Environment and Behavior*, the first interdisciplinary scholarly journal in that field.

XII

Earth and Planetary Sciences

The Corning Glass Works, Corning, N.Y., has announced the appointment of **George Beall**, Ph.D. '62, as the company's first Research Fellow — a new position created "to recognize individuals who have demonstrated the ability to perform independent, innovative research work of high quality that has resulted in significant contributions to the company." . . . **Grant Buma**, S.M. '70, is President of the Rocky Mountain Geochemical Corporation, Midvale, Utah. . . . **Cyril Galvin**, Ph.D. '59, formerly chief of the Coastal Processes Branch at the U.S. Army Coastal Engineering Research Center, is now in private practice as a coastal engineer with offices in Springfield, Va.

XIII

Ocean Engineering

Edwin E. Kintner, S.M. '46, director of the Department of Energy's Office of Fusion Energy, reports that "a major advance toward the goal of using magnetic confinement fusion to generate electric power" has been achieved as a result of a successful experiment conducted at Princeton Plasma Physics Laboratory. The experiment registered record temperature and energy yield in a tokamak fusion device.

James R. Hancock, S.M. '72, has been elected to the office of President and Chief Executive Officer of the Peerless Audio Manufacturing Corp., manufacturers of high-fidelity loudspeaker drivers. . . . **D. C. Klingensmith**, S.M. '57, has been named Chairman of the Division of Engineering Technology at Bluefield State College, Bluefield, W. Va. . . . **Peter Tarpgaard**, S.M. '68, is now Design Superintendent at the Portsmouth Naval Shipyard in New Hampshire. He writes: "Judy and I are happy to be back in New England." . . . **Som D. Sharma**, Research Scientist at the Institut for Schiffbau, University of Hamburg, Germany, will be Visiting Professor in the Department until December, 1978.

What Role for Law in Management?

How should legal issues be incorporated in the curriculum of the Sloan School of Management?

That question motivated an all-day conference in Cambridge early this spring. Six experts in corporate law joined eight members of the faculty in considering what kind of law and how much of it should be required as part of a manager's preparation, and they also gave their views on appropriate research.

Alumni attending included **Paul A. Heinen,** S.M. '56, Vice President, General Counsel, and Secretary of Chrysler Corp.; **Henry H. Perritt, Jr.,** S.M. '70, Assistant General Counsel of Consolidated Rail Corp.; **W. John Swartz,** S.M. '67, Executive Vice President of Santa Fe Industries, Inc.; and **Edgar H. Twine,** S.M. '73, Associate General Counsel of Atlantic Richfield Co.

J. H. Kerrebrock

Kerrebrock: A New Head for Aeronautics and Astronautics

Jack H. Kerrebrock, Richard Cockburn Maclaurin Professor in Aeronautics and Astronautics who is a specialist in propulsion systems for aircraft and spacecraft, will succeed Professor Rene H. Miller as Head of the Department of Aeronautics and Astronautics on July 1.

Professor Miller will return to teaching and research in the field of air transportation, in which he holds the H. N. Slater Professorship.

A member of the faculty since 1960, Professor Kerrebrock is Director of the Department's Gas Turbine and Plasma Dynamics Laboratory, where he has led research programs in many phases of energy conversion related to aircraft propulsion. He holds degrees from Oregon State University (B.S. 1950), Yale (M.S. 1951), and California Institute of Technology (Ph.D. 1956); and from 1956 until 1960 he held research posts at Oak Ridge National Laboratory and Caltech. Professor Kerrebrock is Chairman of the Science and Technology Advisory Group of the Air Force Scientific Advisory Board, a member of the National Research Council's Aeronautics and Space Engineering Board, and a member of the Turbomachinery Committee of the American Society of Mechnical Engineers.

XIV
Economics

Philip Friedman, Ph.D. '72, Associate Professor of Economics at Boston University, recently presented a paper at the annual meeting of the Southern Economic Association. The title of the paper was "The Impact of Joint Ventures: A Pooled Cross-Section Analysis." ... **Manuel Cabrera Kabana,** '60, is President of Kabana, S.A., Madrid, and also partner and member of the executive committee of Dames and Moore, consultants in environmental and earth sciences. He was recently appointed President of Resource Technology and Development Corp., with offices in London, Los Angeles, and Madrid.

Professor **Stanley Fischer,** Ph.D. '69, who rejoined the teaching staff in 1973 after appointments at the University of Chicago and Hebrew University, Jerusalem, is Acting Associate Head of the Department; he was promoted to Professor in July, 1977 ... Massachusetts Governor Michael S. Dukakis has appointed Dr. **Robert M. Solow,** Institute Professor, to the state's Council on the Arts and Humanities, a body of private citizens who work to make cultural resources more accessible to people.

Paul M. Horvitz, Ph.D. '58, has left his position as Assistant to the Chairman of the Federal Deposit Insurance Corporation to become Professor of Finance at the University of Houston. ... **Jagdish N. Bhagwati,** Professor of Economics whose special field is the developing countries and their relationships with the industrial nations, is the author of *The New International Economic Order: The North-South Debate,* published last fall by the M.I.T. Press.

XV
Management

Systems Research Laboratories announce the promotion of **William E. Dirkes,** S.M. '61, to assistant vice president of the Research and Development Department ... **Erskine N. White, Jr.,** S.M. '49, is executive vice president of the Textron Co., which has proposed an Opportunities Industrial Center in South Providence, R.I. The purpose of the Center is to start a manufacturing company, owned and operated by the residents of that part of Providence, a predominantly black area. It was suggested that manufacturers in Rhode Island help launch the new company by granting it exclusive contracts for components needed for its products ... **John J. (Jay) Wetzel II,** SL '73, has been appointed director of quality control of Pontiac Motor Division.

Kenneth Gordon, S.M. '60, Deputy Director of the Office of Telecommunications advises that the office is now part of a new agency within the Department of Commerce. The new agency also includes the White House Office of Telecommunications Policy ... **John R. M. Gordon,** Ph.D. '66, has been appointed Dean of the School of Business at Queen's University in Kingston. Before joining Queen's, he was a member of the faculty at the Institute pour l'Etude des Methods de Direction de l'Enterprise in Lausanne, Switzerland. He will remain a member of the Harvard Advisory Committee on I.M.E.D.E. and act as a consultant to both private corporations and foreign governments. Dr. Gordon's research interests are in the fields of corporate and manufacturing policy and his publications have appeared in many journals.

Philip B. Fletcher, S.M. '70, has been appointed vice president-manufacturing for Heublein Spirits Group. He was formerly general manager of operations at the H. J. Heinz Co. ... **Holmes Bailey,** S.M. '52, is named vice president of marketing at Atlas Copco, the manufacturer of compressed air equipment and hydraulic rock drills in Wayne, N.J. ... **Thomas J. Aylward,** S.M. '74, has been promoted to vice president of manufacturing and international operations at Master Builders in Cleveland.

XVI
Aeronautics and Astronautics

George A. Whiteside, S.M. '46, has been appointed director of program development of Systems Research Laboratories in Dayton, Ohio ... **Robert C. Seamans, Jr.,** Sc.D. '42, former administrator of the U.S. Energy Research and Development Administration, and former President of the National Academy of Engineering, has been appointed Dean of the School of Engineering at M.I.T. Dr. Seamans is noted for his work in the development of guidance and control systems for planes, ships, missiles and space vehicles and had a major leadership role in the conception, planning and carrying out of Project APOLLO.

Lawrence E. Day, S.M. '72, has received his second award of the Meritorious Service Medal. The colonel was cited for outstanding duty and performance as chief ... **Lawrence Levy,** S.M. '48, president of the Northern Energy Corp. in Cambridge, Mass., was the speaker at an Audubon Society meeting devoted to solar energy. Mr. Levy is working on a plan for the implementation of a Northeast Solar Energy Center ... Former astronaut, **Philip K. Chapman,** Sc.D. '67, has joined Arthur D. Little, Inc., as a senior staff member in the Engineering Sciences section. He will specialize in systems analyses of advanced, large-scale energy sources, among these a solar-powered satellite.

Professor **John F. McCarthy, Jr.,** '50, Director of the Center for Space Research, will be on leave from M.I.T. beginning next October 1 to become Director of N.A.S.A.'s Lewis Research Center, Cleveland, Ohio. Dr. McCarthy has had a long career in both business and government; before coming to M.I.T. he was Vice President — Systems Engineering at the Los Angeles Division of Rockwell Corp., and he has held important policy roles in the Air Force and N.A.S.A.

Professor **Eugene E. Covert,** Sc.D. '58, has completed his assignment as Chairman of a committee conducting an independent review of the Shuttle engine program. The committee was formed at the request of N.A.S.A. by the National Research Council's Assembly of Engineering in accordance with a request of the Subcommittee on Science, Technology, and Space of the Senate Committee on Commerce, Science, and Transportation.

Philip K. Chapman, Sc.D. '67, has joined Arthur D. Little, Inc., as a senior staff member in the Engineering Sciences section where he will specialize in systems analyses of advanced, large-scale energy sources. Foremost among them is a solar power satellite which will collect solar energy and beam it back to earth where it is converted into electricity. Dr. Chapman, formerly an astronaut with N.A.S.A., was mission scientist for Apollo 14, responsible for crew training, coordination of experiments, and communication with the crew during that mission. He was later assigned to the Space Shuttle program, and in 1972 he left N.A.S.A. to work for Avco Everett Research Laboratory, Inc., as a principal research scientist where he worked on the development of a rocket engine powered by a ground-based laser for space launch applications. ... **Holt Ashley,** Sc.D. '48, has been elected to the board of directors of Hexcel Corp., developers and manufacturers of honeycomb materials, fiber composites and specialty chemicals. Dr. Ashley holds professorships in the Departments of Aeronautics and Astronautics and Mechanical Engineering of Stanford University.

XVII
Political Science

Lincoln P. Bloomfield, Professor of Political Science at M.I.T., will direct a seminar under the auspices of the National Endowment for the Humanities this summer. The seminar, "Idealism versus Pragmatism in American Foreign Policy," is open to journalists.

Wayne A. Cornelius, Associate Professor of Political Science, was awarded a Citation for Distinguished Scholarly Contribution at this winter's annual meeting of the Latin American Studies Association. Professor Cornelius was recognized for his efforts to increase understanding among policymakers and the U.S. public of the nature and consequences of illegal immigration from Mexico.

William A. Platte, Ph.D. '71, is Deputy to the President at the Naval War College, Newport, R.I. . . . *A Behavioral Study of Rural Modernization: Social and Economic Change in Thai Villages,* by **Charles A. Murray,** Ph.D. '74, has been published by Praeger (New York).

XIX
Meteorology

Robert White, Sc.D. '49, has been elected to a term as a member of the Board of Overseers of Harvard College. He is currently Administrator of the National Oceanic and Atmospheric Administration.

XX
Nutrition and Food Science

A major study on protein, *Protein Resources and Technology,* A.V.I. Publishing Co., is the result of the joint efforts of M.I.T, the National Science Foundation and 220 leading scientists to produce a definitive work on protein resources, problems and research priorities. It is edited by Max Milner, senior lecturer in the Department of Nutrition and Food Sciences at M.I.T. and Nevin S. Scrimshaw, head of the department and Daniel I. C. Wang, a member of the department faculty.

Barbara Underwood, Associate Professor of Nutrition and Director of the Division of Biological Health at Pennsylvania State University, is Visiting Associate Professor in the Department.

Marving F. Grower, Ph.D. '74, has been promoted to Lieutenant Colonel in the U.S. Army Dental Corps; he is Chief of the Department of Biochemistry at the U.S. Army Institute of Dental Research, Washington, D.C., and is a Professorial Lecturer at George Washington University . . . **Kenneth A. Jones,** S.M. '72, is an Associate Product Manager with the Food Service Products Division of General Foods Corporation, White Plains, N.Y. . . . **Bill Kan,** Ph.D. '58, has been named Manager at Higbee Associates, Stamford, Conn., an executive search firm . . . **H. Bourges,** Ph.D. '68, has been elected to the National Academy of Medicine, Mexico, and has become President-elect of the Latin American Nutrition Society, to take the presidency on January 1, 1979.

William Goldman, S.M. '64, is starting his second year of residency at Pennsylvania Hospital where he is specializing in internal medicine and clinical pharmacology.

XXII
Nuclear Engineering

"America is in a desperate energy situation today and Americans have to accept the reality that in addition to conserving energy, we must also improve our capacity to produce," said **Andrew C. Kadak,** Ph.D. '72, in a speech at the Worcester Science Center. He concluded that the realistic alternatives for future energy supplies are coal and nuclear power. Dr. Kadar is nuclear information manager for the New England Electric System.

William H. Reed, Sc.D. '69, who is Assistant Group Leader of the Neutron Transport Theory Group at Los Alamos Scientific Laboratory, is Visiting Associate Professor until May 1; he's been at Los Alamos since completing his graduate degree at the Institute.

Frederick H. Hauck, S.M. '66, is one of 80 finalists for N.A.S.A. Space Shuttle Astronaut Selection. He is currently Executive Officer of Attack Squadron 145, U.S. Navy . . . **Gerald T. Petersen,** Ph.D. '58, is General Manager of the Allis Chalmers Coal Gasification Systems Operation.

Jeffrey Bromberg, S.M. '69, is now a school psychologist working at a boy's detention ranch . . . **Jim Peters,** Nu.E. '69, is working as a freelance artist in Norwich, Conn., where he has received a federal grant as one of the artists hired to enhance the "environmental beauty" of the city.

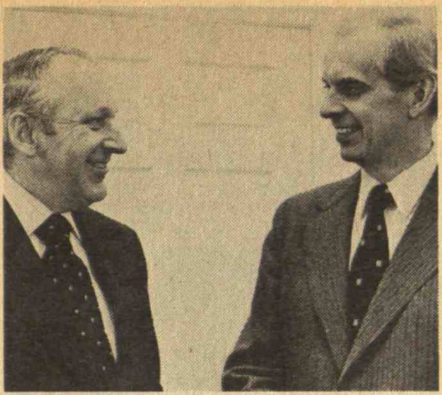
M. J. Harper, S.M. '76, has completed his naval nuclear power training and is assigned to the *U.S.S. Lapon,* a nuclear attack submarine whose home port is Norfolk, Va. . . . **Ken Yoshitani,** Nu.E. '71, has been promoted to Senior Engineer at Fluor Pioneer, a Chicago-based firm which provides engineering, procurement, and construction services for nuclear and fossil-fueled power plants.

XXIII
Linguistics and Philosophy

Fellowships for independent study and research in 1978-79 have been awarded by the National Endowment for the Humanities to **Noam A. Chomsky,** Professor of Linguistics, who will write a book on linguistics theory; **Judith Jarvis Thomson,** Professor of Philosophy, who will continue work on a book, *Rights and Wrongs,* a study of the sources and significance of human rights; **Jay Jackendoff,** Ph.D. '69, Professor of Linguistics at Brandeis, who will study the relationships of linguistics, semantics, and cognitive psychology; and **Scott Soames,** Ph.D. '76, Professor of Philosophy at Yale, whose research will be on the foundations of linguistics.

Donald A. Henriksen, S.M. '68, has been elected Vice President, Government Relations, of Atlantic Richfield Company . . . **Louis Servizio,** S.M. '71, has joined Data Resources with responsibility for marketing of financial services . . . **T. M. St. Clair,** S.M. '58, has been elected President and Chief Operating Officer of Engineered Metal Products Group, Koppers Company, Inc. . . . **A. T. Camp,** S.M. '56, is Chief Technologist for the U.S. Naval Ordinance Station — and he also owns and operates a complete farm and dairy for production and marketing of goat milk . . . **R. C. Youngdahl,** S.M. '63, is Executive Vice President of Energy Supply for Consumers Power Company, Jackson, Mich. . . . In Tehran, Iran, **Thomas Ioerger,** S.M. '75, is Program Development Manager for Westinghouse.

Frank Perna, Jr., S.M. '70, has become Executive Vice President, Operations, at Sun Electric Corporation, and he will direct all of their marketing, manufacturing and engineering activities . . . The Chase Manhattan Bank, New York, N.Y., has named **A. Edward Allinson,** S.M. '71, as Senior Vice President and Department Executive for Trust and Fiduciary Investment . . . **John H. Hubbard,** S.M. '63, has been selected a Corporate Vice President of the Warner & Swasey Company, Cleveland, Ohio.



When Colby H. Chandler, S.M. '63, became President of Eastman Kodak Co. last year, he qualified for an M.I.T. Corporate Leadership Award — an honor established by the M.I.T. Corporation to recognize extraordinary achievements of Institute alumni as leaders of business and industry. The pleasure of making the presentation came early this year to William F. Pounds (right), Dean of the Sloan School of Management, in whose Sloan Fellowship Program Mr. Chandler earned his master's degree.

Management in an Era of Uncertainty: How to Run a Company in the 1980s

The increasingly public arena in which managers must perform . . . the increasingly global arena in which companies do business . . . the ever-growing price of energy and other raw materials . . . the increasing shortage of human resources . . . the possibility of a "major depression" . . .

. . . these are among the challenging issues which will confront management in the 1980s, according to speakers at the M.I.T. Club of Chicago's management conference on May 8.

Attendees at the day-long meeting left with a new understanding of the conference prospectus: "The issue is decision-making under uncertainty. . . . Inflation, unemployment, productivity, and human resource problems will go hand-in-hand. The executive will have to develop new tools to optimize the resources for which he is responsible," wrote Richard A. Jacobs, '56, Chairman of the conference committee.

A major depression in the 1980s? A possibility, says Professor Jay W. Forrester of the Sloan School of Management, reading tentative results of the System Dynamics National Model being developed under his direction at M.I.T. That was just one of the uncertainties which — taken together — represent management's challenge in the 1980s, according to speakers at a conference of the M.I.T. Club of Chicago on May 8. (Photo: E. W. Defell from the Santa Fe Railway)

Operating in the Public Arena

Keynoting the meeting, Richard L. Terrell, Vice Chairman of General Motors Corp., seemed to be saying that tomorrow's problems will not be very different from today's. "Management's challenges, problems, and opportunities in the 1980s for the most part are the challenges, problems, and opportunities that already confront us," he said.

But that does not make the subject dull or unimportant. World interdependence on energy and other materials, and also on markets, is now a fact of life; "the world company — call it a multinational or transnational — is more and more part of the business scene," said Mr. Terrell. He recited General Motors' dependence on raw materials from overseas and — on the other end of the scale — the company's effort to develop a "world car" — the vehicle that carries the name Chevette in the U.S.

Its international ties are but one reason for the increasing public scrutiny of American business. Government interrelationships and controls are a fact of life, he said, and managers in the 1980s will have to tell themselves repeatedly that "we can't be against the government when, fundamentally, the government is us."

A "Great Depression" from the "Long Wave"?

If Mr. Terrell saw only familiar problems for the 1980s, Professor Jay W. Forrester, S.M. '45, Germeshausen Professor of Management at M.I.T., had a very different crystal ball. Reporting on studies of economic behavior using a System Dynamics National Model, Professor Forrester foresaw "the possibility of another major depression" — perhaps as soon as the next decade.

It's not a definite prediction yet, Professor Forrester emphasized, and in the next year his System Dynamics Group will be "carefully examining" the theory out of which that possibility arises. This theory holds that there is a "long wave" of variations in economic activity superimposed on the more familiar, shorter business cycles and that the U.S. is currently at a peak in that "long wave." If that is the case, there is nowhere to go but down — just as there was in the 1830s, 1890s, and 1930s.

But such a depression can be an opportunity, not necessarily a calamity, for the economy, thinks Professor Forrester. He reads from history that "at the onset of a depression ample production capacity exists to raise everyone's standard of living to new heights," and he hopes that the System Dynamics National Model on which his group is now working can reveal "useful clues [for] policy alternatives . . . to keep the end of rebuilding from turning into a depression."

Conquering a Hostile Environment for Innovation

Glen L. Urban, Professor of Management Science in the Sloan School, says the corporate response to future uncertainty should lie in successful new product development. But — like any other — that's a risky response; "competition is increasing, market boundaries are being penetrated, and many market areas are saturated."

Four ways to minimize the risk for management in the 1980s, he said:

☐ Be sure you produce what the customers want; "companies must forge new links between research and development and marketing," he said.

☐ Be sure your new product is right for your company. "Businessmen must learn to use tools which will help them define their markets more carefully."

☐ Concentrate on new design techniques. "Businesses need new ways to formulate ideas [so] that each physical product has a psychological identity."

☐ Seek cost-efficient testing methods. It's now possible to simulate consumer reactions and so avoid the high costs of conventional market testing.

Special Human Needs and Problems

As everything else grows more complex in the 1980s, said Edgar H. Schein, Professor of Organizational Psychology and Management, so will the management of human resources. But it's a crucial issue: "If the organization has the wrong people for the job, or if people work below their potential or fail to learn new skills as organizational needs change, [these things] can make the difference between failure and success." Three special problems in this field, according to Professor Schein:

☐ Human resources management has to be meshed with the management of other resources — money, technology, space, and information, among others.

☐ Human resources are neither passive nor stable. "People react to how they are managed, and they change over time."

☐ Human resources must be varied. "In most organizations the complexity of the task requires a wide variety of people to get the job done. This means that no one approach to human resource management can be applied to everyone," said Professor Schein. ☐

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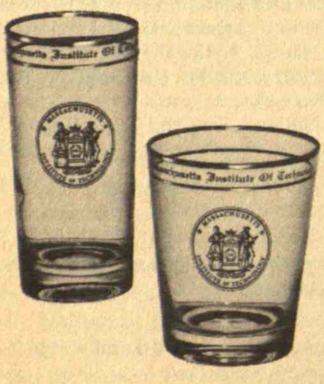

1978

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Under the Domes

"Boston is the national center for intercollegiate athletics of the right kind," said Howard W. Johnson, Chairman of the Corporation, in dedicating the Henry G. Steinbrenner Stadium on April 30, and that day the Greater Boston area gained yet another reason for this preeminence — "a great day for track at M.I.T.," said Mr. Johnson. With him at the dedication were Mr. and Mrs. Steinbrenner and John J. Dillon, '78, Captain of the 1978 M.I.T. track team. (Photo: Calvin Campbell)

1,058 Confirmed in the Class of 1982; More Women and Blacks Than Ever

By mid-May, a little over six weeks after 1,712 applicants had received letters of acceptance, membership in M.I.T.'s Class of 1982 stood at 1,058. The Faculty Council had asked Peter H. Richardson, '48, Director of Admissions, to bring in a class of 1,050, and Mr. Richardson was confident: "The numbers are about where they ought to be," he told Steven Solnick, '81, of *The Tech*.

Based on his figures as of May 15, Mr. Richardson expected 20 per cent of the Class to be women, the highest proportion in the history of the Institute. And at least 7 per cent would be from racial minorities — again the highest ever.

The Rising Cost of Sleeping (7%), Eating (5%), and Going to School (8%)

Responding to inflation, the cost of going to M.I.T. next year will be higher: tuition will be $4,700 for two terms, up from $4,350; a dormitory room in MacGregor House, the Institute's most expensive residence, will cost $1,440 compared to this year's $1,344; and 19 meals a week in the dining halls will cost $1,386 compared with $1,320 this year.

The standard student budget — including tuition, room, board, and books and personal expenses — is set at $8,350. That reflects the fact that rooms in many dormitories cost less than MacGregor — Random House is the least expensive, at $962 — and that few students sign up for the "unlimited-seconds" 19-meal plan in the dining halls. Other options include a 15-meals-a-week, no-seconds plan which will cost $919 next year.

The tuition increase effective this summer is the ninth consecutive annual change, and Paul E. Gray, '54, Chancellor of the Institute, foresees that the series will continue indefinitely. "Unless inflation falls back to something in the range of 1 or 2 per cent," he told William Lasser, '78, of *The Tech*, "we're clearly going to have to increase tuition every year."

Housing and meals charges are calculated to cover the costs of dormitory and dining hall operations, since M.I.T. intends that both services "break even." This year's increases in dormitory rentals reflect the impact of a new sewer tax in Cambridge and the "true cost" of the dormitory telephone system, according to Harold E. Brammer, Director of Housing and Food Services. The increase in meals charges is planned to cover inflation in food costs during the coming year, but as the prices of lettuce and beef climbed late in the spring Mr. Brammer was heard to wonder if his estimates had been high enough.

To match these increases in students' expenses, the Student Aid Financial Office will have an additional $400,000 in unrestricted Institute funds for scholarship grants, and the amounts which students and their parents are expected to provide toward educational expenses will rise — the latter in accordance with the general increases in wages of recent years, according to Jack H. Frailey, '44, Director of Student Aid.

Two other changes affect students' responses to M.I.T.'s higher costs next year:

☐ The Parents Loan Program, initiated a year ago, will be extended. Parents with incomes of between $15,000 and $60,000 may borrow up to $7,000 a year for their children's college expenses, to be repaid over an eight-year period.

☐ All loans made to undergraduate and graduate students which are not guaranteed by federal or other sources will require cosigning by a "credit-worthy loan guarantor." This new policy results from the increasing demand for student loans from M.I.T. sources (necessitating short-term borrowing by the Institute) and from "increasing concern" about the "repayment experience" on M.I.T. funds loaned to students. "Slower-than-expected loan repayments affect the funds available to current students," explains John M. Wynne, S.M. '56, Vice President for Administration and Personnel, who chaired a committee reviewing policy.

Though Dr. Gray admits that it may be "of little comfort now to those upon whom the burden of increasing expenses falls," it is a fact that "as M.I.T. expenses have risen over the years, so has the value of an M.I.T. education.

"This is borne out every year by the salaries paid to M.I.T. graduates," he says.

The Steinbrenners Give M.I.T. a Stadium Built for Doing, not Watching

By dictionary definition, a "stadium" is "a place for athletic exercises." For most universities that means 30,000 or more seats in a bowl overlooking a football field; but for M.I.T. it means a 400-meter polyurethane-rubber running track, Greater Boston's only steeplechase, facilities for all field events except the hammerthrow, and seats for perhaps 600 spectators — a uniquely appropriate response to the special kind of intercollegiate athletics at M.I.T.

The description is of the Steinbrenner Stadium, a gift of George M. Steinbrenner III, Mrs. Judith Kamm, and Mrs. Susan Norpell in honor of their father, Henry G. Steinbrenner, '27. Already in use, it was dedicated on April 30 in the midst of the Greater Boston Outdoor Track Championships.

Acknowledging greetings from Howard W. Johnson, Chairman of the Corporation, and other dignitaries, and speaking especially to the M.I.T. track team waiting to use the stadium, Mr. Steinbrenner asked that M.I.T.'s future athletes "realize that the most important thing is not to have conquered but to have fought well."

Mr. Steinbrenner did both during his intercollegiate career as an M.I.T. undergraduate. He held numerous high- and low-hurdles titles, his career culminating in the National Collegiate 220-yard Championship run in the record time of 23.9 seconds at Franklin Field, Philadelphia, in May, 1927. To this day, that makes him the only M.I.T. man ever to have won an outdoor national track championship.

R. C. Seamans, Jr.

Gordon W. Moore

Robert C. Seamans: From N.A.S.A. and E.R.D.A. to Dean of Engineering

After a search lasting nearly a year, the School of Engineering has a new Dean: **Robert C. Seamans, Jr.,** Sc.D. '51, Henry R. Luce Professor of Environment and Public Policy who was the first Administrator of the Energy Research and Development Administration from 1974 to 1977.

Dr. Seamans succeeds Professor Alfred A. H. Keil, who resigned in August, 1977, after serving six years as Dean of Engineering.

Dr. Seamans' distinguished engineering career began at Harvard, where he earned his first engineering degree in 1939; he then came to M.I.T. for work in aeronautical engineering and instrumentation, and he held teaching and research positions at the Institute for 15 years. Then came five years with RCA before the beginning of a long period of distinguished public service in the management of science and technology.

Dr. Seamans was Associate Administrator from 1960 to 1965 and Deputy Administrator until 1968 of the National Aeronautics and Space Administration, with a major role in conception, planning, and execution of Project Apollo. For four years beginning in 1969 he was Secretary of the Air Force, and for one year thereafter he was President of the National Academy of Engineering, where plans leading to the creation of E.R.D.A. were developed.

Paul E. Gray, '54, Chancellor of M.I.T., notes that Dr. Seamans brings to his new job as Dean of Engineering "a unique blend of engineering, administrative, and managerial experience," and President Jerome B. Wiesner praises the new Dean's "long, distinguished career of public service."

Dr. Seamans is a Fellow of the Institute of Electrical and Electronics Engineers, an Honorary Fellow of the American Institute of Aeronautics and Astronautics, and a Trustee of the National Geographic Society and of the Carnegie Institution of Washington.

New Leadership Campaign Officer for the West

Gordon W. Moore, '60, Founder and President of Gordon W. Moore and Associates, Inc., management consultants, has been named District Officer for the M.I.T. Volunteer Leadership Appeal with responsibility for the western states and the West Coast.

Mr. Moore succeeds Kevin J. Kinsella, '67, who has resigned.

Mr. Moore's M.I.T. degree is in management, and he served in various administrative posts with RCA Information Systems from 1960 to 1969. He then joined Honeywell Information Systems, Inc., as Branch Marketing Manager for three years before organizing the business in which he is now engaged. He is now also President and Chief Executive Officer of Rocky Mountain Transcomm, Inc., a wholly owned subsidiary of the French firm GSI-USA, Inc.

Mr. Moore has been active in alumni affairs, first as Vice President of the M.I.T. Club of San Francisco and more recently as President of the M.I.T. Club of Denver; he is also Chairman of the Colorado State Science Fair.

Raymond H. Blanchard, 1896-1978

Raymond H. Blanchard, '17, retired President of the Hood Rubber Co. who was President of the Alumni Association in 1947-48, died on April 1 in Melrose, Mass. He was 82.

Mr. Blanchard was Vice President of the Alumni Association from 1943 to 1945, and he was active as a member of the Alumni Council both before and after his term as 54th President of the Association; he was also a leader in the early years of the Alumni Fund.

In addition to his responsibilities at Hood Rubber Co., Mr. Blanchard was active in local and regional business; he was a former President of the Associated Industries of Massachusetts, former Chairman of the Board of the First National Bank of Melrose, and a former member of the Investment Committee of the Melrose Savings Bank and of the Planning Board for the Melrose Public Schools.

Frederick E. Broderick, 1897-1978

Frederick E. Broderick, who became a widely known and beloved member of the M.I.T. staff during 54 years of employment at the Institute, died on April 9 at South Shore Hospital, Weymouth, after a long illness. He was 81.

Mr. Broderick's M.I.T. career began in 1913, when he came to work at the Institute in Boston at the age of 16. As a technician in the Department of Electrical Engineering, he worked on such major projects as the Van de Graaff electrostatic generators and the late Vannevar Bush's differential analyzer. He helped the late Professor Carlton E. Tucker manage the original Institute telephone system, and Mr. Broderick was himself responsible for installation of what is now the "dormline" system.

Mr. Broderick was a founder of the Research, Development, and Technical Employees' Union and of the M.I.T. Employees' Federal Credit Union.

Peter W. Forsbergh, Jr., 1922-1978

Peter W. Forsbergh, Jr., '43, who taught electrical engineering at M.I.T. for two years beginning in 1947, died in Comrie, Scotland, on March 20 at the age of 56. After studying and teaching at M.I.T., Mr. Forsbergh joined the London staff of the U.S. Office of Naval Research and since then had lived in Scotland.

George C. Halstead, 1919-1978

George C. Halstead, '40, President of Alcoa Steamship Co. and a member of the Visiting Committee to the Department of Ocean Engineering, died on April 11. A resident of Manhasset, Long Island, he was a major figure in the New York shipping community.

Vyacheslav A. Gorlov, 1959-1978

Several days after he was described by his parents as a "missing person," the body of Vyacheslav A. Gorlov, '79, was discovered on April 9 in the M.I.T. main buildings. He was 19.

Mr. Gorlov, described as a brilliant student, had withdrawn from M.I.T. at the end of the second week of the Spring Term; he had immigrated to the U.S. with his parents from the Soviet Union in 1975, having attended the Moscow State Pedagogical Institute for one year. The coroner ruled Mr. Gorlov's death a suicide.

Deceased

Gilman B. Joslin, '05; March 30, 1978; P.O. Box 5577, Orlando, Fla.
Alfred Mullhaupt, Jr., '09; March 15, 1970.
Merton W. Hopkins, '11; May, 1977; 788 Parkshore Dr., Apt. F-32, Naples, Fla.
Ellis W. Brewster, '13; March 17, 1978; 71 Warren Ave., Plymouth, Mass.
Madison W. Christie, '13; March 24, 1978; 265 C High Point Blvd., Boynton Beach, Fla.
Henry O. Glidden, '13; March 17, 1978; 49 Colonel Hunt Dr., Abington, Mass.
Gordon H. Robb, '13; November, 1974; Run Hill Rd., Brewster, Mass.
Hibbard S. Busby, '14; December 14, 1977; P.O. Box 68, LaGrange, Tex.
Chester P. Davis, '14; May 3, 1973; 6 Jason St., Arlington, Mass.
Walter C. Eberhard, '14; February 16, 1978; 35 Shirley Rd., Waltham, Mass.
Thomas W. Sheehan, '14; April 28, 1978; Harbor Village, Apt. 8 D, Branford, Conn.
Viking Enebuske, '15; March 1, 1978; Fairlawn Nursing Home, 265 Lowell St., Lexington, Mass.
Charles R. Outterson, '15; March 24, 1978; 3925 Chamberlayne Ave., Apt. 2, Richmond, Va.
Charles W. Williams, '15; March 19, 1978; 278 North Ave., Westport, Conn.
Raymond H. Blanchard, '17; April 1, 1978; Elmhurst Nursing Home, 743 Main St., Melrose, Mass.
Hartley B. Gardner, '17; February 8, 1978; 29 Miller Rd., New Haven, Conn.
Ray R. Gauger, '17; May, 1977; 111 E. Kellogg Blvd., #504, St. Paul, Minn.
Forrest M. Hatch, '17; April 2, 1977; c/o C. J. McIntyre, Atty., 1159 Hancock St., Quincy, Mass.
Richard O. Loengard, '17; April 1, 1978; 21 East 87th St., New York, N.Y.
Robert L. Gifford, '18; April 1, 1978; R. R. #1 Box 430, Center Harbor, N.H.
Leslie N. Iredell, '18; October 9, 1969; 6104 River Terrace, Tampa, Fla.
Clarence W. Bates, '19; December 6, 1977; Box 281, Ashland, N.H.
F. Scott Carpenter, '20; March 17, 1978; 83 Simonds Rd., Lexington, Mass.
Mildred Dreyer, '20; September 8, 1977; 408 E. Drury, Kissimmee, Fla.
Harold F. Hunter, '20; November 28, 1977; National City Bank Trust Co., Rome, Ga.
George R. McNear, '20; March 11, 1978; 6731 St. Andrews Dr., Tucson, Ariz.
Scott H. Wells, '20; September 8, 1977; First National Bank of Clearwater, P.O. Box 179, Clearwater, Fla.
James E. Baylis, '21; March 22, 1978; 408 S. 21st Ave., Hattiesburg, Miss.
Hartwell Flemming, '21; December 20, 1977; 31 Cedar Ave., Arlington, Mass.
William C. Kohl, '21; August 20, 1977; 333 University Dr., Apt. 307, Coral Gables, Fla.
Egbert W. Olcott, '21; November 10, 1977; 56 Springtown Rd., Long Valley, N.J.
John N. Worcester, '21; December 17, 1976; Claybrook Rd., Dover, Mass.
Herbert O. Albrecht, '22; December 31, 1977; 62 S. Hillcrest Rd., Springfield, Penn.
Edward A. Ash, '22; September 22, 1975; 405 N.W. 22nd St., Homestead, Fla.
Frederick J. Guerin; '22; March 23, 1978; 737 Riverside Dr., Lawrence, Mass.
Elmer W. Hammond, '22; January 26, 1978; 3332-A Baria Blanca, Laguna Hills, Calif.
John W. Ingram, '22; February 28, 1978; 312 Spring Ave., Ridgewood, N.J.
Dwight F. Johns, '22; November 8, 1977; 55 Park Way, Oakland, Calif.
Manuel Shampanier, '22; March, 1977; 908 Venetia Ave., Coral Gables, Fla.
Milo T. Siverling, '22; January 10, 1978; 13 Woodland Rd., Minneapolis, Minn.
Hilary S. Swenson, '22; September 28, 1977; 88 Shipyard Ln., South Dartmouth, Mass.
Arthur W. Davenport, '23; March 24, 1978; P.O. Box 574, Virginia Beach, Va.
Alvah G. Hayes, '23; December 12, 1977; 23 Holbrook Rd., North Andover, Mass.
Eugene L. Chappell, '24; January 5, 1978; Cemline Corp., Cheswick, Penn.
Gilbert H. Cowan, '24; October 11, 1977; 917 McCandless St., Sault Ste. Marie, Mich.
Stewart B. Luce, '24; March 26, 1978; 322 Park Dr., Glenwood Springs, Colo.
Frank F. Reed, '24; March 25, 1978; 925 E. Villa St., Pasadena, Calif.
Roscoe E. Swift, '24; March 8, 1978; 3004 Hampshire Dr., Augusta, Ga.
Percy H. Wilson, '24; August 2, 1977; P.O. Box 4945, Carmel, Calif.
Ralph E. Winslow, '24; January 14, 1978; 10 Forest Park Ave., Larchmont, N.Y.
Charles E. Jewett, '25; November 14, 1977; 805 Iris Ln., Vero Beach, Fla.
George W. Stetson, Jr., '25; December 9, 1974; Holiday House, Box 258, Montego Bay, Jamaica, W.I.
Allen G. Clarke, '26; November 25, 1977; 2 Musket Trail, Simsbury, Conn.
Amos T. Akerman, '27; 1977; c/o Fairfax Nursing Ctr., 10701 Main St., Fairfax, Va.
Jacob C. Muskin, '27; October 9, 1977; 1621 Nelson Ct., Hewlett, N.Y.
Ralph F. Peterson, '27; March 17, 1978; 1220 Norbee Dr., Normandy Manor, Wilmington, Del.
Winthrop M. Puffer, '27; February 27, 1978; 2900 45th St. South, Gulfport, Fla.
Carl L. Redd, '27; March 18, 1978; 204 Edgevale Rd., Baltimore, Md.
Christopher M. Case, '28; April 18, 1978; 90 Windham St., Willimantic, Conn.
Wilbur L. Gaines, '28; November 23, 1977; 226 Sagamore Rd., Millburn, N.J.
Theodore P. Hall, '28; March 17, 1978; 2006 Orizaba Ave., San Diego, Calif.
Edward W. Roessler, '28; December 30, 1977; Old Mill Rd., R.R. #1, Box 217, Chester, N.J.
Redmond E. Walsh, Jr., '28; September 29, 1977; 12 Myrtle St., Woburn, Mass.
Harry Finkel, '29; February 17, 1972; 46 Allen Park Rd., Springfield, Mass.
Edward R. Harrigan, '29; August 10, 1975; 1548 Shore Club Dr., St. Clair Shores, Mich.
Isidore Winer, '29; February 7, 1978; 46 Grove Ave., Glens Falls, N.Y.
Arthur L. Senior, '30; September 6, 1977; 43 Churchill St., Newtonville, Mass.

Daniel Calkin, '31; March 2, 1978; 16342 Angler Ln., Huntington Beach, Calif.
Walter Gompertz, '31; January 4, 1978; 204 Country St., Rehoboth, Mass.
William P. Kimball, '31; March 17, 1978; P.O. Box 149, Hanover, N.H.
E. Joe Shimek, '31; March 10, 1978; 3760 Willowick Rd., Houston, Tex.
Kennedy H. Clark, '33; April 1, 1978; 435 Club Ln., Louisville, Ky.
Harold W. Russell, '33; February 28, 1978; 739 Cerrito, Berkeley, Calif.
Edward S. Coe, '34; January 4, 1978; 14368 Stahelin, Detroit, Mich.
Henry L. Blatner, '35; February 3, 1978; R.D. #2, Glenmont, N.Y.
Edward P. Chapman, Jr., '35; June 21, 1977; 7712 American Heritage Dr. N.E., Albuquerque, N. Mex.
David U. Sullivan, '35; August, 1976; 15 Fairmount St., Belmont, Mass.
Arthur E. Bearse, '36; November 9, 1977; 2732 N.W. Blvd., Columbus, Ohio.
Webster H. Francis, '36; May, 1974; c/o Mrs. Walter Blank, 27 Hollmount Rd., Rochester, N.Y.
Henry J. Janson, '36; July 4, 1977; 8 Seneca Dr., Danvers, Mass.
John R. Bennett, '38; June 8, 1977; P.O. Box 354, Arlington, Mass.
Carl V. Moberg, '38; December 13, 1977; 446 Range Rd., Towson, Md.
Richard G. Naugle, '39; 1977; 118 S. Market St., Ligonier, Penn.
Louise Odiorne, '39; November 19, 1977; Tech-Stone, Inc., Box 6, Yellow Springs, Ohio.
George C. Halstead, '40; April 11, 1978; 90 Abbey Rd., Manhasset, N.Y.
John O. Hallberg, '41; 1976; 2333 John Baker, Orange, Tex.
Peter W. Forsbergh, Jr., '43; March 20, 1978; Ancaster Arms Hotel Comrie, Stromness, Perthshire, Scotland.
Basil Rabnett, '43; January 25, 1978; The Moorings R.R. #2, Picton, Ontario, Canada.
Wendell P. Turner, Jr., '43; November 28, 1977; 663 Lynn Fells Pkwy., Melrose, Mass.
Russell B. Palmiter, '47; January 27, 1978; Box 208, Accord, Mass.
Tadeusz W. Wlodek, '48; March 2, 1978; 297 Fifth Ave., Ottawa, Ontario, Canada.
William E. Wright, '50; March 9, 1978; 5818 Greenlawn Dr., Bethesda, Md.
Peter W. Sieck, '51; March 28, 1978; 458 Winnetka Ave., Apt. 208, Winnetka, Ill.
George W. Stetson III, '52; August 14, 1977; 1000 N. Miami Ave., Miami, Fla.
Ernest Rifkin, '53; October 27, 1977; 111 Eden Roc Cir., Syracuse, N.Y.
Eldred G. Blakewood, '54; 1975; 825 Elizabeth St., Baton Rouge, La.
Victor A. Lindemann, '56; January 23, 1978; 4 S. Shirley Ave., Moorestown, N.J.
Charles F. Mallory, '56; April 7, 1978; 36 Somerville Ave., Westmount Montreal, Canada.
George Philip Englert, '60; March 11, 1975; 2009 New Jersey, Baytown, Tex.
Jon R. Kelly, '61; April 9, 1978; 104 Martin Rd., Concord, Mass.

hours, during which this debt is being repaid. Thus heart rate is a measure of both the instantaneous exertion and also of any previously incurred oxygen debt. When remote monitoring shows a rapid heart rate, one cannot be certain if the fish is swimming at that moment or collecting oxygen to recover from previous exhaustion.

Our fish studies did not prepare us for the extreme response observed in the heart rate of all fish species. Cardiac arrest, or stopping of the heart, is a fish's response to stress. We found we could trigger it with the subtlest of cues, once the fish had recovered from our initial handling during the attachment of the transmitter. Two examples come to mind.

A plaice, or flounder, which had not eaten for many months, had settled into the sand on the bottom of a large indoor laboratory aquarium. The time was mid-winter, and the water temperatures were low; the fish appeared to be doing the flounder's equivalent of hibernating. But despite this outward lethargy, its heart responded to doors opening, relays clicking, and to any other sort of human activity in the vicinity.

Not unexpectedly, the flounder reacted strongly to visual cues. We experimented with this response, gradually reducing its visual stimulus to smaller objects moved into the flounder's visual field. The strongest responses were elicited early in the morning before local laboratory activity had started. At this time we could come quietly up to the tank and push a pencil a few centimeters over the edge. The heart of the plaice, one and one half meters below, would stop beating for eight or nine seconds.

Another incident concerns a venerable cod, which we had kept in captivity for over a year. It lived in a glass tank with full visibility of the laboratory. It repeatedly had been the unwilling donor of blood samples, and so had largely accommodated to the presence of people. Its heart rarely slowed except when the fish was touched physically. The cod wore an experimental acoustic transmitter. When the transmitter's battery wore out, it was necessary to catch the fish in order to replace the unit. To accomplish this, we started toward the fish with a dip net, one which the fish had never seen. The cod stopped swimming, faced the approaching strange net, and extended its fins in what we had come to recognize as a fright response. Its heart stopped for a full 19 seconds.

Such observations lead us to believe that acoustic telemetry will be a valuable adjunct to behavior and sensory studies. When we have been able to monitor three fish simultaneously, some elements of social interaction showed in their variable heart rate. In particular, competition for food was easily discerned after a few observations of heart response while feeding. In this manner one builds up a behavioral repertoire that will aid in the interpretation of data from a fish swimming freely in the ocean where its behavior cannot be observed.

Frequently animals do things for no obvious reason. They are most likely reacting to stimuli that we are unable to perceive. But telemetered data is providing increasing insight into the actions of some species. I can illustrate this by comparing the cardiac responses of a sea gull with those of a codfish. These contrasting behaviors show up in their telemetered electrocardiograms.

A sea gull must run its metabolism at high speed to meet the high-energy demands of flight. The muscles are dark red; there is much blood in a sea gull. This reflects the need for rapid oxygen transport. A gull can fly long distances without accumulating fatigue. It is always ready to take off soon after it has landed.

A cod, on the other hand, takes a lethargic approach to life. Its muscle is white, because it contains little blood. This situation reflects the animal's general inactivity. When it is fatigued from swimming vigorously for a few seconds, its metabolic recovery may take 12 to 24 hours.

The fish attempts to avoid action, and stops its heart for as long as 15 or 20 seconds when it is frightened. Only reluctantly in pursuit or flight does a cod move rapidly: it knows that activity requires a long recovery. During that recovery period the ability to move fast will be impaired, so the fish will be more vulnerable to its predators.

The pronounced cardiac arrest in fish is a prey-predator response. Lining each side of a fish is a very sensitive low-frequency vibration sensing system, called the lateral line. This senses the movements of other fish in the vicinity. By stopping the heart, and therefore the circulating blood, a cod can use its detection system at higher gain. Otherwise the desired signals would be swamped by the turbulent noise of the fish's own circulation.

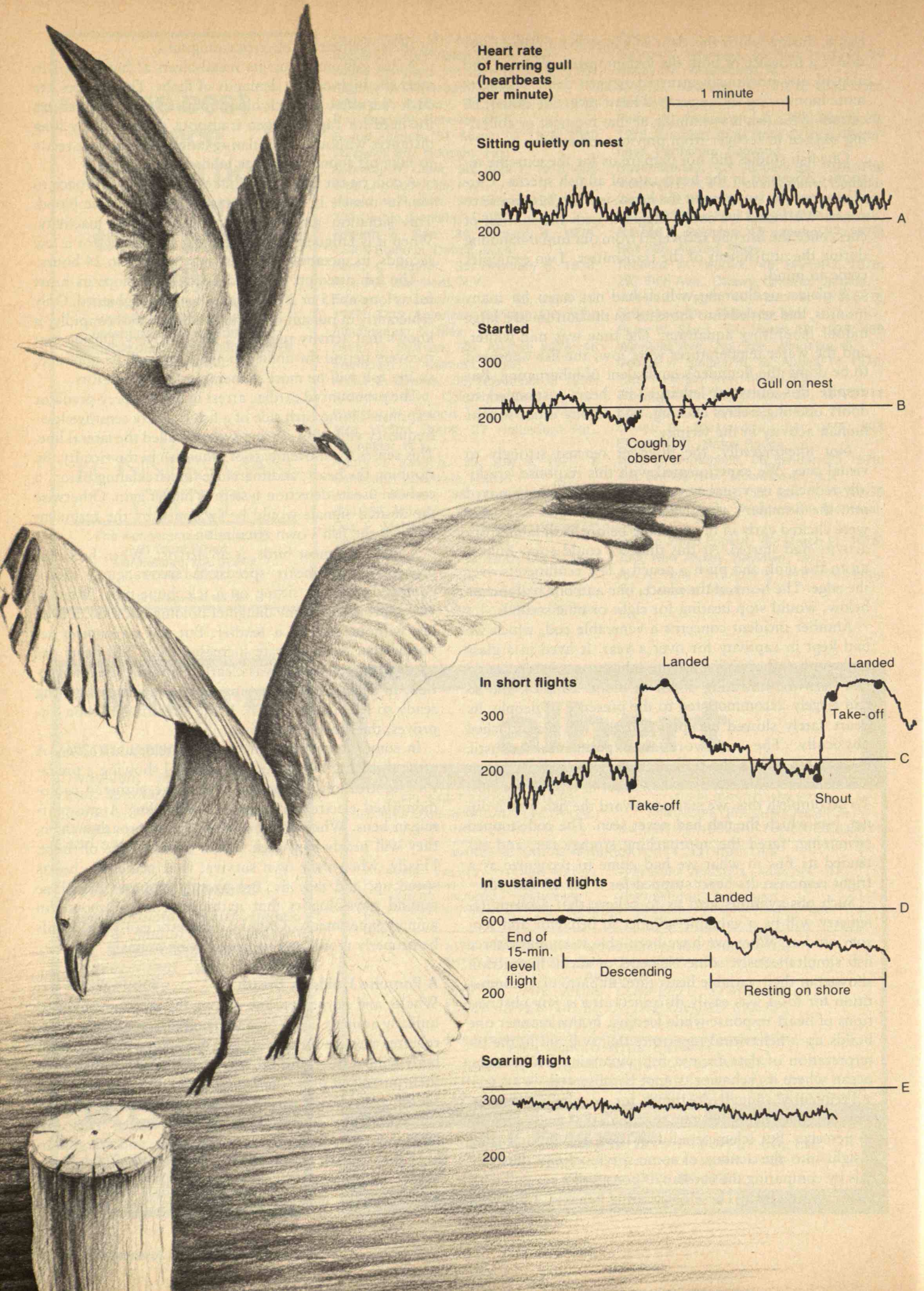
A gull, like most birds, is an activist. When he is apprehensive, his heart speeds. A free-ranging, radio-equipped gull was sitting on a telephone pole. When it was approached by my daughter holding out food, it eyed her without ruffling a feather. But the transmitter reported that its heart rate increased from 120 beats per minute to over 400. It was clearly preparing itself for action. In a sense it was revving up the engine and getting ready to let out the clutch. If the stressful situation improves, the heart slows down.

In some situations even birds are reluctant to flee. A ground-nesting bird stays put to avoid showing a predator the location of her eggs. We have gathered radio-monitored electrocardiograms of brooding Arctic ptarmigan hens. When a dog or a person approaches them, they will nearly stop their hearts for a minute or more. Finally, when their own survival is at stake, the hearts speed up, and they fly. Behavioral responses like these remind physiologists that naturalness is paramount in animal experiments. Only by telemetry can such details be properly monitored in free-ranging animals.

A Porpoise Holds Its Breath

Whales and porpoises rank among the most unusual and unlikely animals in the oceans. Their mammalian heritage requires them to breathe air and maintain a high constant body temperature. But the respiratory needs conflict with their pursuit of prey. They must swim down to feed, and return periodically to the surface to breathe. Sperm whales are the most versatile in this respect. They can hunt their prey at depths of a kilometer, and are able to hold their breath for one to two hours while doing it.

We investigated the physiological details of this breath-holding with the help of trained Navy porpoises.


Heart rate
of herring gull
(heartbeats
per minute)
1 minute
Sitting quietly on nest
300
200
A
Startled
300
200
Gull on nest
B
Cough by
observer
In short flights
Landed
Landed
300
200
Take-off
C
Take-off
Shout
In sustained flights
Landed
D
600
End of
15-min.
level
flight
Descending
200
Resting on shore
Soaring flight
E
300
200

The telemetered heart rate *(left)* of a free-living gull shows variation under the differing conditions of the gull's daily life. The charts are logarithmic plots of instantaneous heart rate vs. time. In **A**, the gull sits quietly in the nesting colony. The heartbeat is modulated with the gull's breathing rate. In **B**, the gull is startled by the quiet cough of an observer in a blind 10 m away. The heart rate during two short flights (**C**) shows gradual acceleration before take off. The pre-flight acceleration is accentuated in the second flight because the bird was startled by a shout from an observer 100 m away. **D** shows the end of an 8.5 km flight requiring sustained flapping of wings. The gull's speed throughout the flight was approximately 40 km per hour. A gliding gull (**E**) shows heartbeats similar to the resting gull in **A**.

These were taught to dive down a thousand feet and turn off a buzzer with their nose upon command. Thus we were certain that the animals really have dived down that far. They then were taught to swim back to the surface and exhale under a collecting funnel, so we could measure the gas composition of their lungs. They knew that the reward of three fish would not be given unless their performance was flawless. During the dive the animals carried a sound transmitter which allowed us to monitor their electrocardiograms.

The use of acoustic telemetry with porpoises can affect the animal's behavior. The sound frequencies we use are within their hearing range; to the porpoises, this may be unpleasant. The possibility also arises that, upon realizing they are listening to their own heartbeat, the animals will be fascinated, and vary the rate for their own amusement.

From this and similar work, we are beginning to discover why porpoises have breath-holding skills superior to those of other animals. The brain of the porpoise can be deprived of oxygen for short periods; while humans can deny oxygen to their muscles, as in sprinting 100 yards, they lose consciousness immediately when oxygen is not supplied to the brain. In effect, the porpoise runs the chemistry of its brain in the same manner as we run our muscles. Such an adaptation is logical; without it, the porpoise would drown the first time it didn't get back to the surface on schedule. Humans, of course, do just that. But we are not often faced with the need for diving for our dinners in the open ocean.

Additional diving adaptations show up in the telemetered details of heartbeats. On diving, the porpoise's heart slows down. Once the oxygen in the lungs is used up, it finds little need to keep its blood moving. On the porpoise's return to the surface, the heart immediately speeds up. Now, with oxygen in the lungs, the accumulated CO_2 in the muscles must be moved to the lungs for expiration. The high heart rate is maintained until this recovery process is completed. During this period the porpoise will refuse another command to dive, knowing its body is not ready. Most research as this would be impossible without acoustic telemetry, solid state timers, and such. The research devices we build are mostly one of a kind, but their electronic circuits are more or less conventional. Difficult compromises between power and operating life, as well as between complexity and compactness, must always be made. All underwater devices have to be cast in epoxy resin to eliminate moisture problems. And, since the instruments are usually throw-away devices, the cost must be minimized.

We are often forced to work with solid state devices designed for commercial products. Sometimes these fit our needs exactly. One good example is the COSMOS oscillator and divider, used in electronic wrist watches. These give us a fish-tracking sound transmitter several orders of magnitude more precise in frequency and pulse rate. The 30-millisecond output pulse for the stepper-motor drive is used to form pulses of the 32.768 kHz oscillator. With such a transmitter we know precisely where to tune the receiver. And we can use changes in the arrival time of the pulse to tell whether the fish is moving towards or away from the tracking boat. We are always watching the new integrated circuit releases with the hope of other such fortuitous spin-offs. The micropower medical implant devices are one promising source.

My efforts at blending biology with industrial electronics usually turn out to be both economically and conceptually awkward. I rarely have the money, and if I did, it is difficult to get engineers to accept the constraints inherent in the problem. One incident will illustrate.

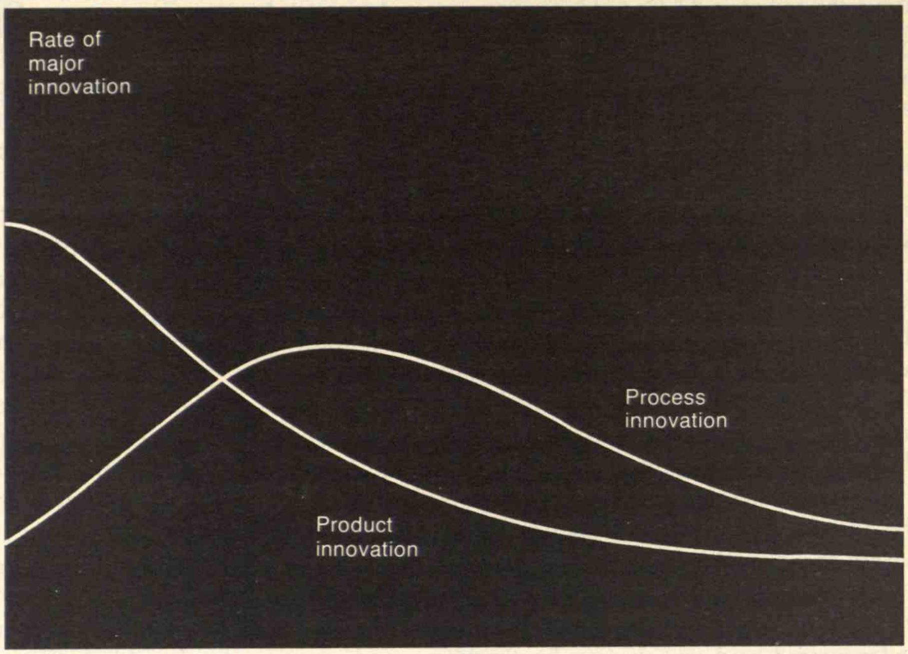
An enthusiastic hybrid circuit designer offered free help in building an acoustic temperature transmitter to be fed to a seal. I never could make him realize that his elegant design wouldn't be able to navigate the tight turns in the animal's gut. There has been little free help worth having in my biological studies. But I am thankful for the commercial fallout, such as the electronic watch chips, which are directly useful.

Biologists are now taking research electronics to sea in small boats. This is an exciting time in the history of solid state technology to be conducting sophisticated marine studies.

For 25 years, **John Kanwisher** has used Woods Hole Oceanographic Institution as a base from which to explore the comparative physiology of free-ranging ocean animals. Calling himself "essentially an engineer," he holds three patents on electronic devices; the proceeds from these often fund his expeditions. He taught oceanography at M.I.T. intermittently from 1961 through 1973. Dr. Kanwisher received his Ph.D. in biophysics from the University of Rochester.

Innovaha!tion

The changing character of innovation, and its changing role in corporate advance. Seeking to understand the variables that determine successful strategies for innovation, the authors focus on three stages in the evolution of a successful enterprise: its period of flexibility, in which the enterprise seeks to capitalize on its advantages where they offer greatest advantages; its intermediate years, in which major products are used more widely; and its full maturity, when prosperity is assured by leadership in several principal products and technologies.



	Fluid pattern	Transitional pattern	Specific pattern
Competitive emphasis on	Functional product performance	Product variation	Cost reduction
Innovation stimulated by	Information on users' needs and users' technical inputs	Opportunities created by expanding internal technical capability	Pressure to reduce cost and improve quality
Predominant type of innovation	Frequent major changes in products	Major process changes required by rising volume	Incremental for product and process, with cumulative improvement in productivity and quality
Product line	Diverse, often including custom designs	Includes at least one product design stable enough to have significant production volume	Mostly undifferentiated standard products
Production processes	Flexible and inefficient; major changes easily accommodated	Becoming more rigid, with changes occurring in major steps	Efficient, capital-intensive, and rigid; cost of change is high
Equipment	General-purpose, requiring highly skilled labor	Some subprocesses automated, creating "islands of automation"	Special-purpose, mostly automatic with labor tasks mainly monitoring and control
Materials	Inputs are limited to generally-available materials	Specialized materials may be demanded from some suppliers	Specialized materials will be demanded; if not available, vertical integration will be extensive
Plant	Small-scale, located near user or source of technology	General-purpose with specialized sections	Large-scale, highly specific to particular products
Organizational control is	Informal and entrepreneurial	Through liaison relationships, project and task groups	Through emphasis on structure, goals, and rules

Patterns of Industrial Innovation

Letter, marked copy, + 10 extra copies; letter
copy " " " " to Utterback

William J. Abernathy
James M. Utterback

A new model suggests how the character of its innovation changes as a successful enterprise matures; and how other companies may change themselves to foster innovation as they grow and prosper.

How does a company's innovation — and its response to innovative ideas — change as the company grows and matures?

Are there circumstances in which a pattern generally associated with successful innovation is in fact more likely to be associated with failure?

Under what circumstances will newly available technology, rather than the market, be the critical stimulus for change?

When is concentration on incremental innovation and productivity gains likely to be of maximum value to a firm? In what situations does this strategy instead cause instability and potential for crisis in an organization?

Intrigued by questions such as these, we have examined how the kinds of innovations attempted by productive units apparently change as these units evolve. Our goal was a model relating patterns of innovation within a unit to that unit's competitive strategy, production capabilities, and organizational characteristics.

This article summarizes our work and presents the basic characteristics of the model to which it has led us. We conclude that a productive unit's capacity for and methods of innovation depend critically on its stage of evolution from a small technology-based enterprise to a major high-volume producer. Many characteristics of innovation and the innovative process correlate with such an historical analysis; and on the basis of our model we can now attempt answers to questions such as those above.

A Spectrum of Innovators

Past studies of innovation imply that any innovating unit sees most of its innovations as new products. But that observation masks an essential difference: what is a product innovation by a small, technology-based unit is often the process equipment adopted by a large unit to improve its high-volume production of a standard product. We argue that these two units — the small, entrepreneurial organization and the larger unit producing standard products in high volume — are at opposite ends of a spectrum, in a sense forming boundary conditions in the evolution of a unit and in the character of its innovation of product and process technologies.

One distinctive pattern of technological innovation is evident in the case of established, high-volume products such as incandescent light bulbs, paper, steel, standard chemicals, and internal-combustion engines, for examples.

The markets for such goods are well defined; the product characteristics are well understood and often standardized; unit profit margins are typically low; production technology is efficient, equipment-intensive, and specialized to a particular product; and competition is primarily on the basis of price. Change is costly in such highly integrated systems because an alteration in any one attribute or process has ramifications for many others.

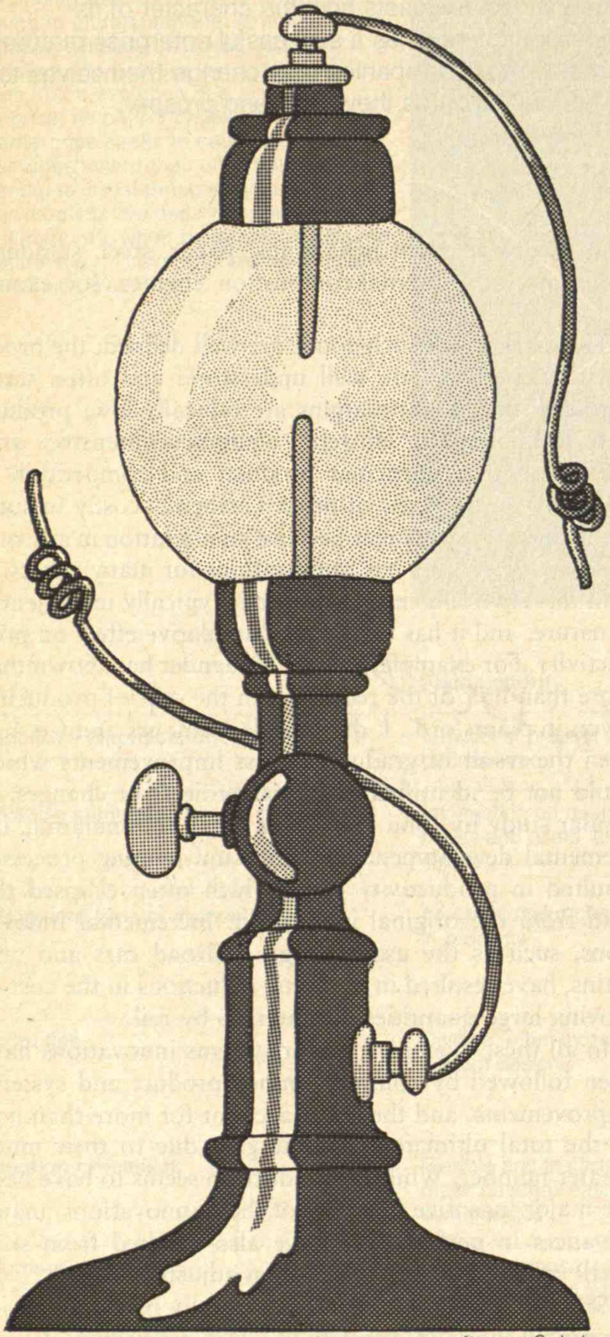
In this environment innovation is typically incremental in nature, and it has a gradual, cumulative effect on productivity. For example, Samuel Hollander has shown that more than half of the reduction in the cost of producing rayon in plants of E. I. du Pont de Nemours and Co. has been the result of gradual process improvements which could not be identified as formal projects or changes. A similar study by John Enos shows that accumulating, incremental developments in petroleum refining processes resulted in productivity gains which often eclipsed the gain from the original innovation. Incremental innovations, such as the use of larger railroad cars and unit trains, have resulted in dramatic reductions in the cost of moving large quantities of materials by rail.

In all these examples, major systems innovations have been followed by countless minor product and systems improvements, and the latter account for more than half of the total ultimate economic gain due to their much greater number. While cost reduction seems to have been the major incentive for most of these innovations, major advances in performance have also resulted from such small engineering and production adjustments.

Such incremental innovation typically results in an increasingly specialized system in which economies of scale in production and the development of mass markets are extremely important. The productive unit loses its flexibility, becoming increasingly dependent on high-volume production to cover its fixed costs and increasingly vulnerable to changed demand and technical obsolescence.

Major new products do not seem to be consistent with this pattern of incremental change. New products which require reorientation of corporate goals or production facilities tend to originate outside organizations devoted to a "specific" production system; or, if originated

Major innovations usually go through countless minor product and systems improvements. . . . Such incremental innovations typically produce a highly specialized system that depends upon economies of scale and mass marketing for success.



Cameron Gerlach

within, to be rejected by them.

A more fluid pattern of product change is associated with the identification of an emerging need or a new way to meet an existing need; it is an entrepreneurial act. Many studies suggest that such new product innovations share common traits. They occur in disproportionate numbers in companies and units located in or near affluent markets with strong science-based universities or other research institutions and entrepreneurially oriented financial institutions. Their competitive advantage over predecessor products is based on superior functional performance rather than lower initial cost, and so these radical innovations tend to offer higher unit profit margins.

When a major product innovation first appears, performance criteria are typically vague and little understood. Because they have a more intimate understanding of performance requirements, users may play a major role in suggesting the ultimate form of the innovation as well as the need *(see "Users as Innovators," by Eric A. von Hippel, January, pp. 30-34)*. For example, Kenneth Knight shows that three-quarters of the computer models which emerged between 1944 and 1950, usually those produced as one or two of a kind, were developed by users.

It is reasonable that the diversity and uncertainty of performance requirements for new products give an advantage in their innovation to small, adaptable organizations with flexible technical approaches and good external communications, and historical evidence supports that hypothesis. For example, John Tilton argues that new enterprises led in the application of semiconductor technology, often transferring into practice technology from more established firms and laboratories. He argues that economies of scale have not been of prime importance because products have changed so rapidly that production technology designed for a particular product is rapidly made obsolete. And R. O. Schlaifer and S. D. Heron have argued that a diverse and responsive group of enterprises struggling against established units to enter the industry contributed greatly to the early advances in jet aircraft engines.

A Transition from Radical to Evolutionary Innovation

These two patterns of innovation may be taken to represent extreme types — in one case involving incremental change to a rigid, efficient production system specifically designed to produce a standardized product, and in the other case involving radical innovation with product characteristics in flux. They are not in fact rigid, independent categories. Several examples will make it clear that organizations currently considered in the "specific" category — where incremental innovation is now motivated by cost reduction — were at their origin small, "fluid" units intent on new product innovation.

John Tilton's study of developments in the semiconductor industry from 1950 through 1968 indicates that the rate of major innovation has decreased and that the type of innovation shifted. Eight of the 13 product innovations he considers to have been most important during that period occurred within the first seven years, while the

industry was making less than 5 per cent of its total 18-year sales. Two types of enterprise can be identified in this early period of the new industry — established units that came into semiconductors from vested positions in vacuum tube markets, and new entries such as Fairchild Semiconductor, I.B.M., and Texas Instruments, Inc. The established units responded to competition from the newcomers by emphasizing process innovations. Meanwhile, the latter sought entry and strength through product innovation. The three very successful new entrants just listed were responsible for half of the major product innovations and only one of the nine process innovations which Dr. Tilton identified in that 18-year period, while three principal established units (divisions of General Electric, Philco, and R.C.A.) made only one-quarter of the product innovations but three of the nine major process innovations in the same period. In this case process innovation did not prove to be an effective competitive stance; by 1966 the three established units together held only 18 per cent of the market while the three new units held 42 per cent. Since 1968, however, the basis of competition in the industry has changed; as costs and productivity have become more important, the rate of major product innovation has decreased, and effective process innovation has become an important factor in competitive success. For example, by 1973 Texas Instruments which had been a flexible, new entrant in the industry two decades earlier and had contributed no major process innovations prior to 1968, was planning a single machine that would produce 4 per cent of world requirements for its integrated-circuit unit.

Like the transistor in the electronics industry, the DC-3 stands out as a major change in the aircraft and airlines industries. Almarin Phillips has shown that the DC-3 was in fact a cumulation of prior innovations. It was not the largest, or fastest, or longest-range aircraft; it was the most economical large, fast plane able to fly long distances. All the features which made this design so completely successful had been introduced and proven in prior aircraft. And the DC-3 was essentially the first commercial product of an entering firm (the C-1 and DC-2 were produced by Douglas only in small numbers).

Just as the transistor put the electronics industry on a new plateau, so the DC-3 changed the character of innovation in the aircraft industry for the next 15 years. No major innovations were introduced into commercial aircraft design from 1936 until new jet-powered aircraft appeared in the 1950s. Instead, there were simply many refinements to the DC-3 concept — stretching the design and adding appointments; and during the period of these incremental changes airline operating cost per passenger-mile dropped an additional 50 per cent.

The Unit of Analysis

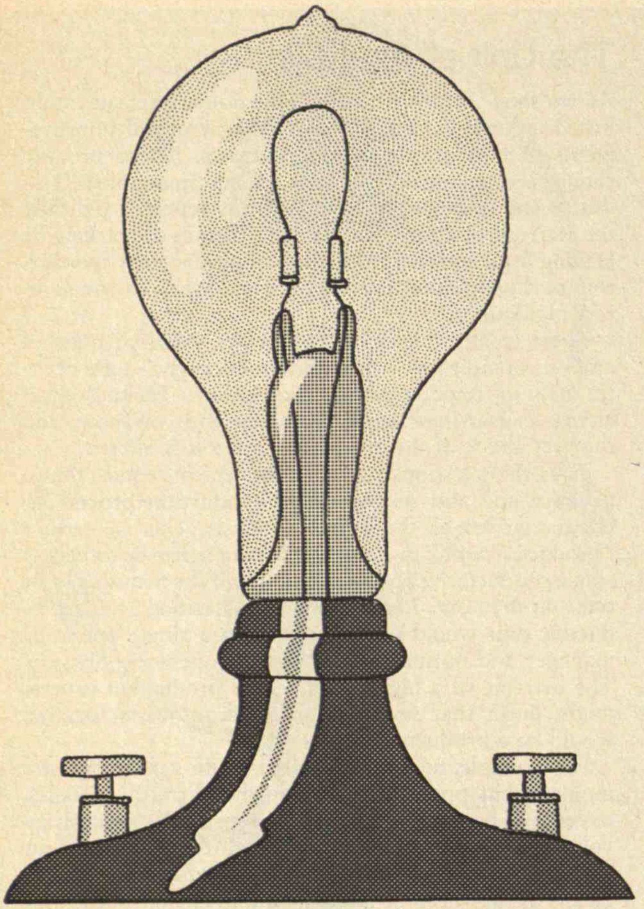
As we show in this article, innovation within an established industry is often limited to incremental improvements of both products and processes. Major product change is often introduced from outside an established industry and is viewed as disruptive; its source is typically the start-up of a new, small firm, invasion of markets by leading firms in other industries, or government sponsorship of change either as an initial purchaser or through direct regulation.

These circumstances mean that the standard units of analysis of industry — firm and product type — are of little use in understanding innovation. Technological change causes these terms to change their meaning, and the very shape of the production process is altered.

Thus the questions raised in this article require that a product line and its associated production process be taken together as the unit of analysis. This we term a "productive unit." For a simple firm or a firm devoted to a single product, the productive unit and the firm would be one and the same. In the case of a diversified firm, a productive unit would usually report to a single operating manager and normally be a separate operating division. The extreme of a highly fragmented production process might mean that several separate firms taken together would be a productive unit.

For example, analysis of change in the textile industry requires that productive units in the chemical, plastics, paper, and equipment industries be included. Analysis involving the electronics industry requires a review of the changing role of component, circuit, and software producers as they become more crucial to change in the final assembled product. Major change at one level works its way up and down the chain, because of the interdependence of product and process change within and among productive units. Knowledge of the production process as a system of linked productive units is a prerequisite to understanding innovation in an industrial context. — *W.J.A., J.M.U.*

The electric light bulb also has a history of a long series of evolutionary improvements which started with a few major innovations and ended in a highly standardized commodity-like product. By 1909 the initial tungsten filament and vacuum bulb innovations were in place; from then until 1955 there came a series of incremental changes — better metal alloys for the filament, the use of "getters" to assist in exhausting the bulb, coiling the filaments, "frosting" the glass, and many more. In the same period the price of a 60-watt bulb decreased (even with no inflation adjustment) from \$1.60 to 20 cents each, the lumens output increased by 175 per cent, the direct labor content was reduced more than an order of magnitude, from 3 to 0.18 minutes per bulb, and the production process evolved from a flexible job-shop configuration, in-



volving more than 11 separate operations and a heavy reliance on the skills of manual labor, to a single machine attended by a few workers.

Product and process evolved in a similar fashion in the automobile industry. During a four-year period before Henry Ford produced the renowned Model T, his company developed, produced, and sold five different engines, ranging from two to six cylinders. These were made in a factory that was flexibly organized much as a job shop, relying on trade craftsmen working with general-purpose machine tools not nearly so advanced as the best then available. Each engine tested a new concept. Out of this experience came a dominant design — the Model T; and within 15 years 2 million engines of this single basic design were being produced each year (about 15 million all told) in a facility then recognized as the most efficient and highly integrated in the world. During that 15-year period there were incremental — but no fundamental — innovations in the Ford product.

In yet another case, Robert Buzzell and Robert Nourse, tracing innovations in processed foods, show that new products such as soluble coffees, frozen vegetables, dry pet foods, cold breakfast cereals, canned foods, and precooked rice came first from individuals and small organizations where research was in progress or which relied heavily upon information from users. As each product won acceptance, its productive unit increased in size and concentrated its innovation on improving manufacturing, marketing, and distribution methods which extended rather than replaced the basic technologies. The major source of the latter ideas is now each firm's own research and development organization.

The shift from radical to evolutionary product innovation is a common thread in these examples. It is related to the development of a dominant product design, and it is accompanied by heightened price competition and increased emphasis on process innovation. Small-scale units that are flexible and highly reliant on manual labor and craft skills utilizing general-purpose equipment develop into units that rely on automated, equipment-intensive, high-volume processes. We conclude that changes in innovative pattern, production process, and scale and kind of production capacity all occur together in a consistent, predictable way.

Though many observers emphasize new-product innovation, process and incremental innovations may have equal or even greater commercial importance. A high rate of productivity improvement is associated with process improvement in every case we have studied. The cost of incandescent light bulbs, for example, has fallen more than 80 per cent since their introduction. Airline operating costs were cut by half through the development and improvement of the DC-3. Semiconductor prices have been falling by 20 to 30 per cent with each doubling of cumulative production. The introduction of the Model T Ford resulted in a price reduction from $3,000 to less than $1,000 (in 1958 dollars). Similar dramatic reductions have been achieved in the costs of computer core memory and television picture tubes.

Managing Technological Innovation

If it is true that the nature and goals of an industrial unit's innovations change as that unit matures from pioneering to large-scale producer, what does this imply for the management of technology?

We believe that some significant managerial concepts emerge from our analysis — or model, if you will — of the characteristics of innovation as production processes and primary competitive issues differ. As a unit moves toward large-scale production, the goals of its innovations change from ill-defined and uncertain targets to well-articulated design objectives. In the early stages there is a proliferation of product performance requirements

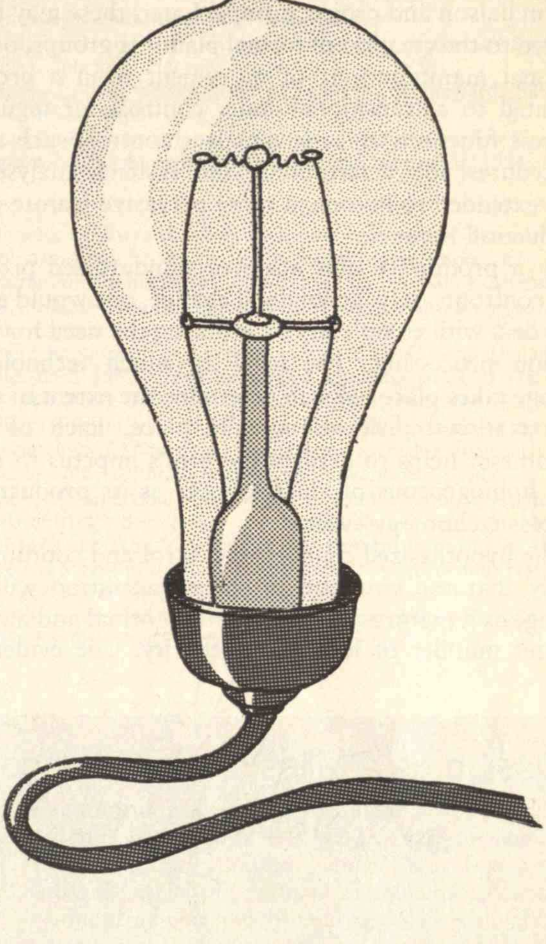
and design criteria which frequently cannot be stated quantitatively, and their relative importance or ranking may be quite unstable. It is precisely under such conditions, where performance requirements are ambiguous, that users are most likely to produce an innovation and where manufacturers are least likely to do so. One way of viewing regulatory constraints such as those governing auto emissions or safety is that they add new performance dimensions to be resolved by the engineer — and so may lead to more innovative design improvements. They are also likely to open market opportunities for innovative change of the kind characteristic of fluid enterprises in areas such as instrumentation, components, process equipment, and so on.

The stimulus for innovation changes as a unit matures. In the initial fluid stage, market needs are ill-defined and can be stated only with broad uncertainty; and the relevant technologies are as yet little explored. So there are two sources of ambiguity about the relevance of any particular program of research and development — target uncertainty and technical uncertainty. Confronted with both types of uncertainty, the decision-maker has little incentive for major investments in formal research and development.

As the enterprise develops, however, uncertainty about markets and appropriate targets is reduced, and larger research and development investments are justified. At some point before the increasing specialization of the unit makes the cost of implementing technological innovations prohibitively high and before increasing cost competition erodes profits with which to fund large indirect expenses, the benefits of research and development efforts would reach a maximum. Technological opportunities for improvements and additions to existing product lines will then be clear, and a strong commitment to research and development will be characteristic of productive units in the middle stages of development. Such firms will be seen as "science based" because they invest heavily in formal research and engineering departments, with emphasis on process innovation and product differentiation through functional improvements.

Although data on research and development expenditures are not readily available on the basis of productive units, divisions, or lines of business, an informal review of the activities of corporations with large investments in research and development shows that they tend to support business lines that fall neither near the fluid nor the specific conditions but are in the technologically-active middle range. Such productive units tend to be large, to be integrated, and to have a large share of their markets.

A small, fluid entrepreneurial unit requires general-purpose process equipment which is typically purchased.



As it develops, such a unit is expected to originate some process-equipment innovations for its own use; and when it is fully matured its entire processes are likely to be designed as integrated systems specific to particular products. Since the mature firm is now fully specialized, all its major process innovations are likely to originate outside the unit.

But note that the supplier companies will now see themselves as making product — not process — innovations. From a different perspective, George Stigler finds stages of development — similar to those we describe — in firms that supply production-process equipment. They differ in the market structure they face, in the specialization of their production processes, and in the responsibilities they must accept in innovating to satisfy their own needs for process technology and materials.

The organization's methods of coordination and control change with the increasing standardization of its products and production processes. As task uncertainty confronts a productive unit early in its development, the unit must emphasize its capacity to process information

by investing in vertical and laterial information systems and in liaison and project groups. Later, these may be extended to the creation of formal planning groups, organizational manifestations of movement from a product-oriented to a transitional state; controls for regulating process functions and management controls such as job procedures, job descriptions, and systems analyses are also extended to become a more pervasive feature of the production network.

As a productive unit achieves standardized products and confronts only incremental change, one would expect it to deal with complexity by reducing the need for information processing. The level at which technological change takes place helps to determine the extent to which organizational dislocations take place. Each of these hypotheses helps to explain the firm's impetus to divide into homogeneous productive units as its products and process technology evolve.

The hypothesized changes in control and coordination imply that the structure of the organization will also change as it matures, becoming more formal and having a greater number of levels of authority. The evidence is strong that such structural change is a characteristic of many enterprises and of units within them.

Design as a Milestone of Change

The milestone in all the examples of transition in the accompanying article is a dominant new product synthesized from individual technological innovations introduced independently in prior products. This dominant design has the effect of enforcing standardization so that production economies can be sought. Then effective competition begins to take place on the basis of cost as well as of product performance.

Similar product design milestones can be identified in other product lines: sealed refrigeration units for home refrigerators and freezers, effective can-sealing technology in the food canning industry and the standardized diesel locomotive in the locomotive and railroad industry. In each case the milestone signals a significant transformation, affecting the type of innovation which follows it, the source of information, and the size, scope, and use of formal research and development.

In an earlier article in this series, George R. White (*see his "Management Criteria for Effective Innovation," February, pp. 14-23*) contends that dominant designs can be recognized in the early stages of their development. His analysis suggests that dominant designs will more likely display one or more of the following qualities:

☐ Technologies which lift fundamental technical constraints limiting the prior art while not imposing stringent new constraints.

☐ Designs which enhance the value of potential innovations in other elements of a product or process.

☐ Products which assure expansion into new markets. — *W.J.A., J.M.U.*

Fostering Innovation by Understanding Transition

Assuming the validity of this model for the development of the innovative capacities of a productive unit, how can it be applied to further our capacity for new products and to improve our productivity?

We predict that units in different stages of evolution will respond to differing stimuli and undertake different types of innovation. This idea can readily be extended to the question of barriers to innovation; and probably to patterns of success and failure in innovation for units in different situations. The unmet conditions for transition can be viewed as specific barriers which must be overcome if transition is to take place.

We would expect new, fluid units to view as barriers any factors that impede product standardization and market aggregation, while firms in the opposite category tend to rank uncertainty over government regulation or vulnerability of existing investments as more important disruptive factors. Those who would promote innovation and productivity in U.S. industry may find this suggestive. (*See "Why Innovations Fail," by Sumner Myers and Eldon Sweezy, March/April, pp. 40-46.*)

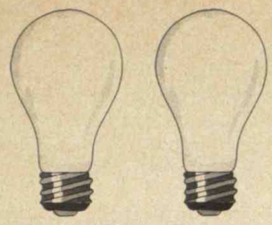
We believe the most useful insights provided by the model apply to production processes in which features of the products can be varied. The most interesting applications are to situations where product innovation is competitively important and difficult to manage; the model helps to identify the full range of other issues with which the firm is simultaneously confronted in a period of growth and change.

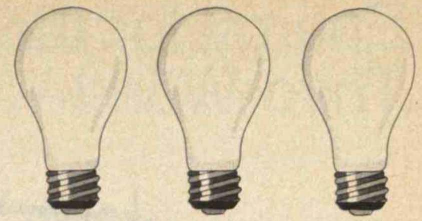
Consistency of Management Action

Many examples of unsuccessful innovations point to a common explanation of failure: certain conditions necessary to support a sought-after technical advance were not present. In such cases our model may be helpful because it describes conditions that normally support advances at each stage of development; accordingly, if we can compare existing conditions with those prescribed by the model we may discover how to increase innovative success. For example, we may ask of the model such questions as these about different, apparently independent, managerial actions:

☐ Can a firm increase the variety and diversity of its product line while simultaneously realizing the highest possible level of efficiency?

☐ Is a high rate of product innovation consistent with an effort to substantially reduce costs through extensive backward integration?





☐ Is government policy to maintain diversified markets for technologically active industries consistent with a policy that seeks a high rate of effective product innovation?

☐ Would a firm's action to restructure its work environment for employees so that tasks are more challenging and less repetitive be compatible with a policy of mechanization designed to reduce the need for labor?

☐ Can the government stimulate productivity by forcing a young industry to standardize its products before a dominant design has been realized?

The model prompts an answer of "no" to each of these questions; each question suggests actions which the model tells us are mutually inconsistent. We believe that as these ideas are further developed they can be equally effective in helping to answer many far more subtle questions about the environment for innovation, productivity, and growth.

Further Readings

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When Transition is Invisible — or Even Absent

Identifying the evolutionary transition from product to process innovation is sometimes troublesome. In some cases the transition may have occurred so rapidly as to be unrecognized; this appears to be the case with some continuous-flow processes where advanced, elaborate, and large-scale equipment is necessary to make a new product virtually from its initial introduction. Rapid transition is also characteristic of certain products with low unit values, such as cigarettes and simple plastic and metal parts, where the availability of a process technology may have made the product feasible in the first place.

More interesting cases are those where the transition from product to process innovation and from unit production to mass production, though predicted, has not come about. Examples include home construction, nuclear power, and some other energy alternatives. In each of these examples, experimental programs to stimulate cost reductions, greater standardization, or other aspects of transition have been undertaken under government and private sponsorship; but none has had long-run impact. These cases are of special interest because the model may help in identifying barriers and pinpointing appropriate responses. — *W.J.A., J.M.U.*

Energy for the Third World

William F. Martin
Frank J. P. Pinto

Letter, marked copy, and 10 extra copies to each author

Copy of letter + marked copy to Prof. Carroll L. Wilson, Bldg E40 MIT

Over 100 developing nations are striving for rapid economic growth. They hope for a good portion of the world's diminishing energy resources. How can we help these nations meet their goals despite ever-sharper competition for oil, gas, coal, and uranium?

Today's developed nations claimed their positions of industrial leadership in an era that is now past. As they were developing, the cost of energy was declining in relation to the cost of most other industrial inputs, and future energy supplies seemed certain. But what of the developing countries, the nations of Africa, Latin America, and Asia, which now seek to achieve industrial growth under very different conditions? To what extent are their aspirations in jeopardy, and how may their futures depend on the wisdom and enlightenment of the established industrial nations?

The developing countries contain about 70 per cent of the total population of the non-Communist world, but in 1972 they accounted for only about 15 per cent of total non-Communist energy consumption. As these countries industrialize, their demand for energy will rise relatively faster than that of the industrialized world. According to the global supply-demand analysis conducted by the Workshop on Alternative Energy Strategies (W.A.E.S.) at M.I.T. in 1976 and 1977, the developing countries could consume as much as 25 per cent of total world energy by the year 2000.

The 93 developing nations considered in this analysis are divided into two major groups:

☐ The 13 oil-exporting countries, members of the Organization of Petroleum Exporting Countries (O.P.E.C.); and

☐ The 80 non-O.P.E.C. developing nations. These consist of 27 low-income countries, primarily in South Asia and East/Central Africa, where per capita annual income is below $200 U.S. (1972 dollars); and 53 middle-income countries of East and West Asia, Latin America, and West Africa, none of whose per capita income is higher than $1,000.

Estimating the Imbalance Between Supply and Demand

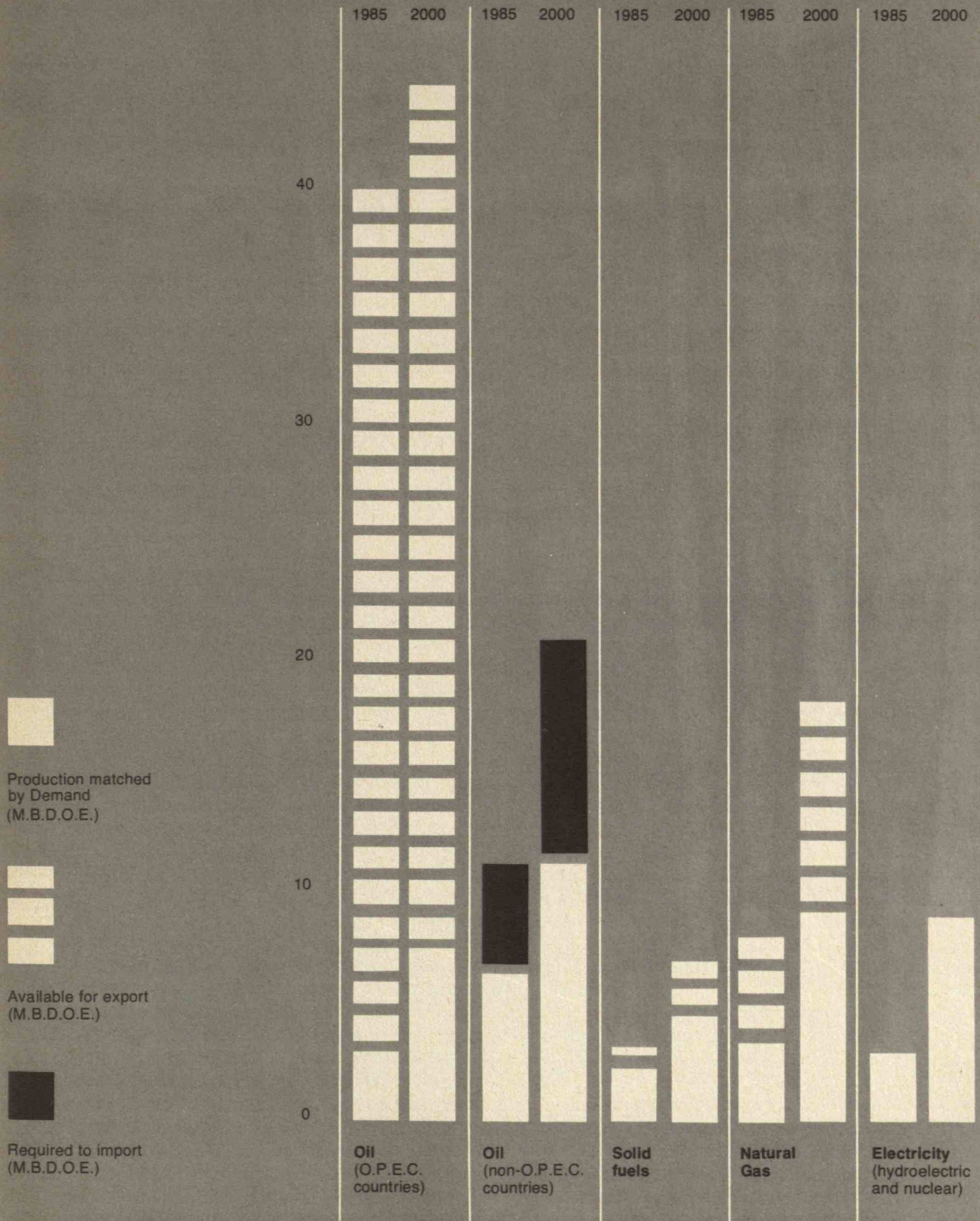
Several assumptions are necessary to project future energy demand. In the W.A.E.S. study of developing nations, we assumed a constant real energy price to 1985, and we analyzed two possible energy-price scenarios — low and high — from 1985 to 2000. (By low energy prices we meant oil at prices not exceeding $11.50 [1976 dollars] per barrel; the high-energy-price scenario was based on oil prices as high as $17.25 per barrel, with the principal replacement fuels for oil when unavailable being coal or nuclear.) We studied scenarios in these developing countries based on high and low world economic growth to 1985 and from 1985 to 2000. In all these scenarios we assumed average annual population growth in the developing countries to the year 2000 of 2.4 to 2.7 per cent, compared to 0.7 to 0.9 per cent for the industrialized world. Non-Communist world population was around 2.7 billion in 1975, and according to our estimates this figure will increase to 4.5 billion by 2000. The industrialized nations claimed approximately 28 per cent of the total population in 1975 and will probably have about 20 per cent by the year 2000.

To characterize future economic growth in the developing nations, we used the World Bank's SIMLINK Model. SIMLINK is a medium-term forecasting system in which exports of non-O.P.E.C. developing countries are related to growth in the developed economies through a series of individual commodity models (rice, copper, tin, beef, etc.). Growth in the developing countries is linked to investment levels and imports; imports in turn depend on export earnings and inflows of foreign capital. SIMLINK can be run to determine the import-constrained growth rates or to determine the additional capital needed to reach higher growth targets.

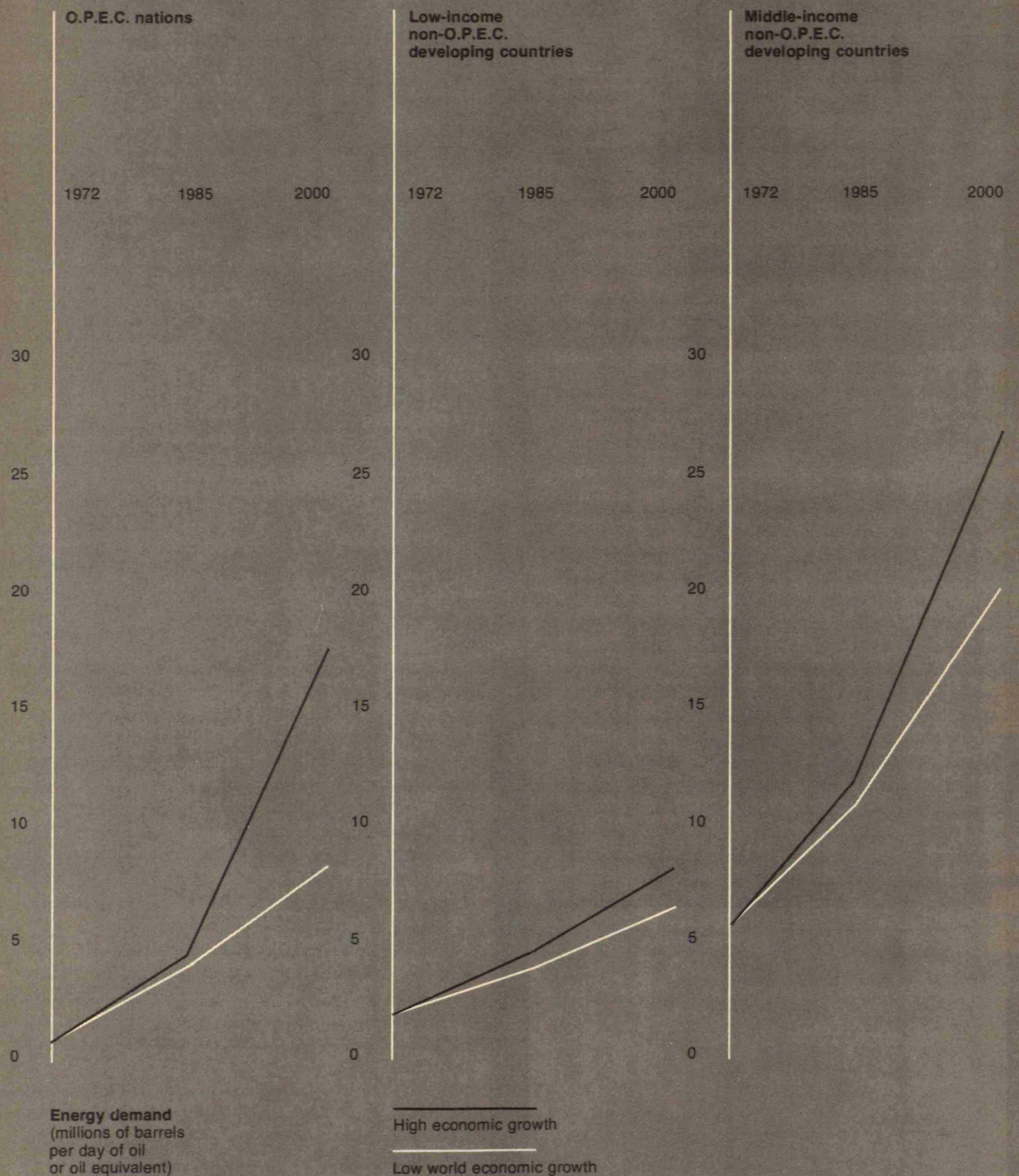
To use SIMLINK, we assumed both high and low economic growth rates in the developed economies; then we derived growth rates for the developing countries on the basis of these two assumptions. We then used the historical (1960-1972) relationship between regional economic growth and energy consumption — the income elasticity of demand — to estimate projected future pri-

The original study on which this analysis is based was performed by the Workshop on Alternative Energy Strategies (W.A.E.S.) conducted at M.I.T. in 1975-77 *(see "The Coming Energy Shortage," by Paul S. Basile and David Sternlight, June, 1977)*. The goal of W.A.E.S. was to estimate demand and potential supplies in the non-Communist nations of the principal fuels which would be important during the last quarter of this decade — oil, gas, coal, and nuclear power — and to discover and quantify prospective gaps between energy demand and supply in these nations. The original report of this work is a chapter in *Energy: Global Prospects 1985-2000;* a more technical presentation may be found in the W.A.E.S. report, *Energy Supply-Demand Integrations to the Year 2000*. The analysis and conclusions of this article are those of the authors and do not represent the views of either the International Energy Agency or the World Bank.

While the O.P.E.C. countries will continue to export vast quantities of oil, most other developing countries will require increasing amounts of imported energy during the remainder of this century. These charts show W.A.E.S. estimates of energy supply and demand in the developing countries in 1985 (left) and 2000 (right), assuming conditions of high world economic growth. The non-O.P.E.C. countries' shortfall of oil — the preferred fuel — will be 4 million barrels a day in 1985 and 9.4 million barrels by 2000, and these countries' production of solid fuels and electricity at the rates shown will depend on effective technology transfer and substantial capital investments from the developed nations.



Rising energy demand is certain in the developing countries by the year 2000. These estimates, by the World Bank and the Workshop on Alternative Energy Strategies (W.A.E.S.) at M.I.T., show present and future energy needs under two scenarios of high and low energy prices and general conditions of growth and prosperity between now and the year 2000. At a minimum, total energy needs in the developing world will rise from under 10 million barrels of oil equivalent a day in 1972 to 35 million barrels in the year 2000.



mary energy demand for low- and high-growth scenarios. On the basis of these estimates, we predicted the total primary energy consumption of developing countries in 1985 and 2000.

On the supply side, we estimated total available energy resources by fuel type — oil, coal, nuclear, etc. — in the developing countries. Our estimates for the period 1975 to 1985 came from World Bank analyses and from W.A.E.S. studies; those for 1985 to 2000 came primarily from the W.A.E.S. global supply studies.

Having estimated energy supplies and energy demand under several scenarios, we attempted supply-demand integrations to balance available energy supplies and expected energy needs. The resulting figures show ranges of fuel surpluses — materials available for export — and shortages to be met by imports.

As a group, the non-O.P.E.C. developing countries are expected to maintain a growth rate higher than that of developed countries through the rest of this century. In the long run, the 53 middle-income developing countries are expected to grow 1 to 2 per cent faster, and the 27 low-income countries about 0.5 per cent slower than the developed nations.

Several of the middle-income countries in Latin America and East Asia profited by the commodity boom of 1972-73 and should be able to achieve comparatively rapid growth over the next decade. The lower-income countries will grow more slowly, because they will continue to suffer from the effects of higher oil prices and agricultural shortfalls. Indeed, economic growth in these countries may be lower than population growth, which implies decreasing per capita incomes between now and the year 2000.

O.P.E.C. countries are expected to achieve high economic growth rates between now and 1985, possibly as high as 7.2 per cent annually. Several O.P.E.C. countries — those with larger populations such as Algeria, Ecuador, Indonesia, Iran, Iraq, Nigeria, and Venezuela — may run deficits in their balances of payments by 1985, but until then most O.P.E.C. countries will have strongly favorable balances of trade and payments. Between 1985 and 2000, O.P.E.C. growth rates except in the richest of these nations (Saudi Arabia and Kuwait) are likely to decrease; many of these countries have undertaken large development projects that may cause foreign exchange shortages and curtailed growth after 1985.

The Rising Curve of Energy Development

From 1960 to 1972 the nations of the developing world more than doubled their consumption of commercial energy, and they increased their demand for electric power by more than 250 per cent. Total commercial energy demand within the developing world (including O.P.E.C.) in 1972 was equivalent to approximately 9.5 million barrels per day of oil equivalent (M.B.D.O.E.). Sixteen of the 93 countries — Argentina, Brazil, Chile, Colombia, Egypt, India, Indonesia, Iran, Korea, Mexico, Pakistan, Philippines, Taiwan, Thailand, Turkey, and Venezuela — together accounted for about three-quarters of this total. In several of the developing countries noncommercial energy in the form of firewood, cow dung, and vegetable waste — not included in this study — constitutes a significant share of total energy consumption. In India, for example, this source provided 59 per cent of total energy in 1960 and 48 per cent in 1970. It is safe to predict that a significant though decreasing percentage of total energy needs will continue to come from such sources.

How Economic Growth Will Affect Energy Growth

The most difficult issue in estimating future energy demand is to establish the relationship between future real economic growth and future energy consumption. The price of oil quadrupled between 1972 and 1976; this increase, and other escalations assumed in the W.A.E.S. cases to 1985, will stimulate conservation and other moves to reduce the energy intensiveness of economic activity. For the period from 1985 to 2000, the high-economic-growth scenario assumes a further 50 per cent increase in real energy prices which should spur even greater energy conservation.

A World Bank study by its economist A. Lambertini in 1976 leads to an interesting and important conclusion: the process of industrialization that raises per capita income also results in a gradual reduction in the growth rate of energy consumption with respect to growth in real income.

Such a simple relationship between economic growth and energy growth fails to include factors that may significantly affect energy consumption, such as changes in the industrial structure or increased mechanization in agriculture. For developing countries achieving rapid industrialization, the production of energy-intensive goods (such as iron and steel, cement, and aluminum) would have to grow even faster than the economy as a whole, and energy demand for a given level of income growth would accordingly be higher than any international average.

This raises the important issue of whether or not developing countries will develop energy-intensive industries. Some feel that many energy-intensive industries may in the future be transferred from today's industrialized nations to developing countries endowed with energy resources. For example, a significant share of the indus-

trialized world's aluminum processing industry might be relocated in Brazil, where abundant hydroelectric reserves would allow for large-scale, relatively inexpensive production; likewise, many chemical plants might be "exported" to the O.P.E.C. countries where abundant gas reserves permit manufacturing of chemicals such as ammonia at lower cost. On the other hand, there are those who feel that developing countries, sensitive to the implications of increasing prices and decreasing supplies of energy resources, will emphasize low-energy alternatives in development — extensive use of "soft" energy technologies supporting smaller, decentralized industry.

The W.A.E.S. studies accepted neither hypothesis, assuming that unconstrained future development in the Third World will follow the familiar course of the present industrial nations. We did not assume major transfer of energy-intensive industries; we believe that the immense complications of such transfers — for both the developed and the developing countries — mean that most developing countries will continue to be net importers of energy-intensive products. Most developing countries did not initiate significant energy-intensive industries when oil prices were low, and the higher prices assumed by the W.A.E.S. cases would presumably further discourage major investment in energy-intensive industry.

Our results based on these assumptions show that non-O.P.E.C. developing countries are expected to achieve an average economic growth rate of between 4 and 5 per cent per year from now until the year 2000 and to increase their energy consumption from four to as high as five times 1972 levels by the year 2000. O.P.E.C. countries are expected to increase their energy consumption five- to eight-fold by the year 2000 based on an economic growth rate of between 6 and 7 per cent per year. The details of these results for the W.A.E.S. high- and medium-oil-price and economic growth scenarios are shown in the chart on page 50.

Estimating Energy Supplies for the Third World

It is difficult to generalize for over 90 countries. In discussing energy supply, we must obviously distinguish between O.P.E.C. and non-O.P.E.C. developing economies. Even within these two groups differences are substantial. O.P.E.C. countries differ widely in their economic growth potentials, development plans, population, and revenue needs. The non-O.P.E.C. developing countries also vary greatly in their energy supply potentials and revenue needs. Some, such as Mexico and Brazil, may be able to attain a high degree of self-sufficiency in terms of energy resources; others, particularly the low-income countries of Africa and Asia, will continue to depend heavily on energy imports.

As the chart (page 55) shows, the middle-income non-O.P.E.C. countries are relatively well endowed with energy resources, especially oil and natural gas. The lower-income countries do not have abundant supplies of oil and natural gas but have large coal reserves. Higher energy prices will encourage new exploration for fuel resources — especially oil, natural gas, and coal — in many developing countries where production has previously been considered uneconomic.

Oil in the Developing Countries

O.P.E.C. countries currently account for about 80 per cent of world non-Communist proven oil reserves — about 450 billion barrels. O.P.E.C. oil production in 1975 was about 27 million barrels per day, most of which was exported to Western Europe, Japan, and North America. Assuming that additions to their reserves over the next 25 years average 10 billion barrels annually and that they continue to meet the import requirements of the major consuming countries at levels projected in the W.A.E.S. studies, the O.P.E.C. countries could be producing 57 million barrels per day by 1995.

However, it is likely that these countries will decide for economic, conservation, or other reasons to limit their production to a level below this theoretical maximum. W.A.E.S. therefore chose three alternative assumptions to represent possible ceilings to total O.P.E.C. oil production: 33, 40, and 45 million barrels a day. The first assumption is a "what if" case in the W.A.E.S. analysis which we cannot really justify. The second assumption appears to be more likely if future additions to reserves are low (5 billion barrels) and oil prices remain constant; while the third assumption is more likely if additions to reserves are high (10 billion barrels) and oil prices rise.

These levels define the maximum potential production of oil by O.P.E.C. Once O.P.E.C. oil production reaches such a limit, it is assumed to remain at that level until depletion results in declining O.P.E.C. production.

Proven oil reserves in non-O.P.E.C. developing countries are about 40 billion barrels — 7 per cent of total non-Communist world reserves. However, the geographical area covered by these nations is vast and relatively unexplored for oil. Extensive exploration motivated by high prices and the need to reduce dependence on imported oil could lead to significant production. W.A.E.S. postulated that 4 billion barrels a year would represent a high future discovery rate. This would permit production at more than triple today's levels, reaching 11.5 million barrels a day by 2000. A less optimistic discovery rate (around 2 billion barrels a year) would probably allow oil production twice as high as current levels by the year 2000.

Although the potential for increased oil discovery and production is large, several problems must be resolved before significant increases in production can be achieved. They include:

□ The financing and building of the exploration, production, and transport infrastructure in remote areas of the world.

□ The negative political attitudes in some developing countries towards the importation of "western" industrial management systems and "western" technology.

□ The lack of confidence in the developed nations which precludes long-term capital investment. Many countries seem politically unstable and therefore inhospitable to foreign capital, and many leaders who seem to have ambitious, short-sighted development goals must be persuaded of the need to create changed conditions and to plan for benefits which will not be realized until the mid-to-late 1980s.

Most non-O.P.E.C. oil production will be limited to a few countries. Three countries — Mexico, Brazil, and Egypt — could account for as much as 40 per cent of such non-O.P.E.C. oil production by 1985, and production in Mexico alone could be one-third of the non-O.P.E.C. developing-country production by 2000. Thus, despite the fact that we can postulate increasing non-O.P.E.C. oil production in the developing countries as a whole, the problem of many of these individual countries who will continue to face large oil import bills and corresponding balance-of-payments deficits remains unresolved.

Self-Sufficiency in Natural Gas

Proven O.P.E.C. natural gas reserves are estimated at 140 billion barrels of oil equivalent — about 60 per cent of all gas reserves in the non-Communist world. At present there is only a limited demand within O.P.E.C. for natural gas, but this will change. The O.P.E.C. countries will increasingly use this plentiful, inexpensive, and convenient fuel, so that 3 to 5 M.B.D.O.E. could be consumed domestically by 2000; Iran has already announced plans to increase natural gas from 18 per cent to as high as 35 per cent of its total primary energy consumption by 1987.

Western Europe, North America, and Japan may increasingly count on O.P.E.C. gas reserves for their energy needs. We estimated maximum potential natural gas imports from O.P.E.C. to the developed nations in 1985 at about 3.5 M.B.D.O.E. If all planned projects are realized, about 2.5 M.B.D.O.E. could be delivered as liquefied natural gas (L.N.G.); this would require O.P.E.C. production of 3.3. M.B.D.O.E. for export, allowing for 25 per cent losses in processing. Another 0.6 M.B.D.O.E. could be delivered by pipeline from North Africa and the Middle East, resulting in a total of 3.9 M.B.D.O.E. of O.P.E.C. gas exports. If all import demands of the major consuming countries are to be met in the year 2000 by O.P.E.C., then these countries would need to produce as much as 9 M.B.D.O.E. for export in addition to the 5 M.B.D.O.E. needed to meet their own internal demands.

Proven reserves of natural gas are sufficient to support such a large expansion in international trade. Uncertainties lie only in the attitudes of the O.P.E.C. countries toward export in contrast to domestic use of gas resources (including use as a chemical feedstock), the availability of capital for investment in L.N.G. systems, and possible constraints due to fear of accidents in L.N.G. commerce.

Despite natural gas reserves of approximately 20 billion barrels of oil equivalent, current natural gas consumption in non-O.P.E.C. developing countries is small. The World Bank reports that only about 65 per cent of the gas produced in 1973 was marketed; the remaining was either flared, vented, or reinjected. Reserves have remained largely undeveloped due to the lack of markets. With rare exceptions, natural gas has been produced only to meet export demand or to maintain pressure in oil fields. Only Afghanistan, Bolivia, and Brunei have been small exporters of natural gas.

But non-O.P.E.C. gas consumption is increasing — from 4 to 8 per cent of non-O.P.E.C. energy between 1960 and 1974 — and gas production and consumption will continue to increase. W.A.E.S. projected that by the year 2000 the non-O.P.E.C. developing countries would reach 4.5 M.B.D.O.E. of gas production — a level which would satisfy domestic needs and also allow for some export.

Coal: Unexploited and Even Unknown

Most of the coal discovered in the world so far lies in the northern temperate zone — in the U.S., the U.S.S.R., and China. Few of the developing countries have ever had to search for coal, since their development began after oil was generally available. Only two of the non-O.P.E.C. developing countries — India and Korea — now mine significant amounts of coal; in these nations, coal accounts for about 50 and 70 per cent, respectively, of total commercial energy consumption.

There could be significant coal reserves in other parts of the developing world, and rising oil prices may encourage non-O.P.E.C. developing countries to seek and exploit such reserves. If the search is successful, coal could help meet domestic energy needs and might possibly contribute to exports. The W.A.E.S. estimate is that coal production in the non-O.P.E.C. nations could reach 230 million tons by 1985 and as much as 510 million tons by

2000; about half of this production would come from India.

These levels would require new mines and handling facilities, the capital costs of which would be high. But the rising cost of imported oil would clearly motivate developing countries, especially lower-income countries with large reserves of coal, to develop this energy source.

Electricity: The Energy Everyone Wants

Electrical capacity nearly tripled in the developing world between 1960 and 1973, when primary electricity production was 2.2. M.B.D.O.E. By the year 2000, total installed electrical capacity in a high-growth future could be as great as 16.5 M.B.D.O.E.

Reserves of hydroelectric power are abundant in developing countries, and hydroelectricity constituted about 44 per cent of the non-O.P.E.C. developing countries' electrical generation in 1972. But only 4 per cent of these countries' hydroelectrical potential is now being utilized, and W.A.E.S. projects hydroelectric capacity to increase over four-fold by 2000.

Similarly, nuclear power *could* grow rapidly. Original estimates (December, 1975) of the International Atomic Energy Agency for nuclear capacity in the developing countries (O.P.E.C. and non-O.P.E.C.) in the year 2000 were as high as 416 gigawatts (electric), enough to supply more than half of all electricity demand. But there are now indications that installed nuclear capacity may be no more than half this; the changed outlook results from uncertainty about U.S. uranium supply and recycling facilities in the wake of President Carter's moves to reduce the threat of proliferation, the increasing capital cost of nuclear plants, and the growing realization in developing countries that nuclear is an inefficient power source for rural economies where users are small and dispersed.

We now tend to accept a low-growth nuclear scenario proposing 148 gigawatts (electric) capacity by 2000; this reduced reliance on nuclear power would be possible if reserves of coal and hydroelectricity are extensively utilized.

Energy Demand: How Much Oil and How Much Coal?

How will these estimated energy resources in the developing countries be used in the next quarter-century?

To answer that crucial question, W.A.E.S. used a method of comparing desired demands and potential supplies which we called supply-demand integrations. We studied energy demand in various sectors — transport, industry, domestic, and commercial — and for non-energy uses, assuming that energy use in each sector would grow at about the same rate as total energy demand. Then we assigned fuels of choice to each sector in accordance with need. Oil was used to fill almost all transportation requirements; the industrial sector's fuel needs in 1985 are met by substantial amounts of oil (42 per cent) and gas (24 per cent, based on the expectation of successful gas exploration in some developing countries), some coal, and — near the end of the current century — some electricity. Requirements of the domestic and commercial sectors are met substantially by oil and electricity. Non-energy needs for feedstocks and asphalt represent demands for oil and some gas.

Shortages and Surplusses: Imports and Exports

The results of comparing prospective energy production and energy consumption in the developing countries according to the two W.A.E.S. scenarios — low and high economic growth — are illustrated in the chart on page 50.

It is clear that O.P.E.C. countries as a whole will continue to be large exporters of fuel, with total oil exports of 33 to 37 million barrels of oil a day in 1985 and 35 to 39 million barrels in 2000. Some O.P.E.C. countries, such as Venezuela and Indonesia, will have growing domestic needs that will limit their exports, but the countries of the Arabian Peninsula have the potential to maintain very high export levels. O.P.E.C. countries with plentiful gas reserves could export large quantities of gas, but this depends on whether they and the importing countries elect to build the expensive and complicated systems needed for producing and handling liquefied natural gas.

Non-O.P.E.C. developing countries have traditionally been large importers of energy; during the period between 1960 and 1972 they imported about 30 per cent of their overall energy needs, and for this reason fuel price increases of the last five years have had serious effects on many developing nations' economies. Our projections show that in 1985 these countries will have to import 18 to 22 per cent, and by 2000 15 to 25 per cent, of their energy needs.

But these non-O.P.E.C. developing countries will differ widely in their dependence on energy imports. Some, such as Mexico and Brazil, may be able to achieve energy self-sufficiency. But most will continue to depend on imports — especially of oil; and given unconstrained development scenarios these countries might desire as much as 4 million barrels a day of imported oil in 1985 and between 7.6 and 9.4 million barrels a day in the year 2000. This last figure is slightly more than Saudi Arabia's current level of oil production. The O.P.E.C. nations' own internal oil requirements could be as much as 8 million barrels a day by 2000. Other W.A.E.S. analyses showed that the industrialized nations might be seeking up to 42 million barrels a day of O.P.E.C. oil by the year 2000. Thus total non-Communist oil demand in 2000 would be about 65 mil-

lion barrels a day, distributed among the developed economies (42), the developing nations (10), the O.P.E.C. nations (8), and international bunkers (5). If O.P.E.C. oil production is 45 million barrels a day, as we proposed earlier in this article, there is in prospect a "gap" of around 20 million barrels a day between oil demand and supply in the year 2000. If Soviet-bloc countries should enter the market as oil importers, the picture would become even bleaker.

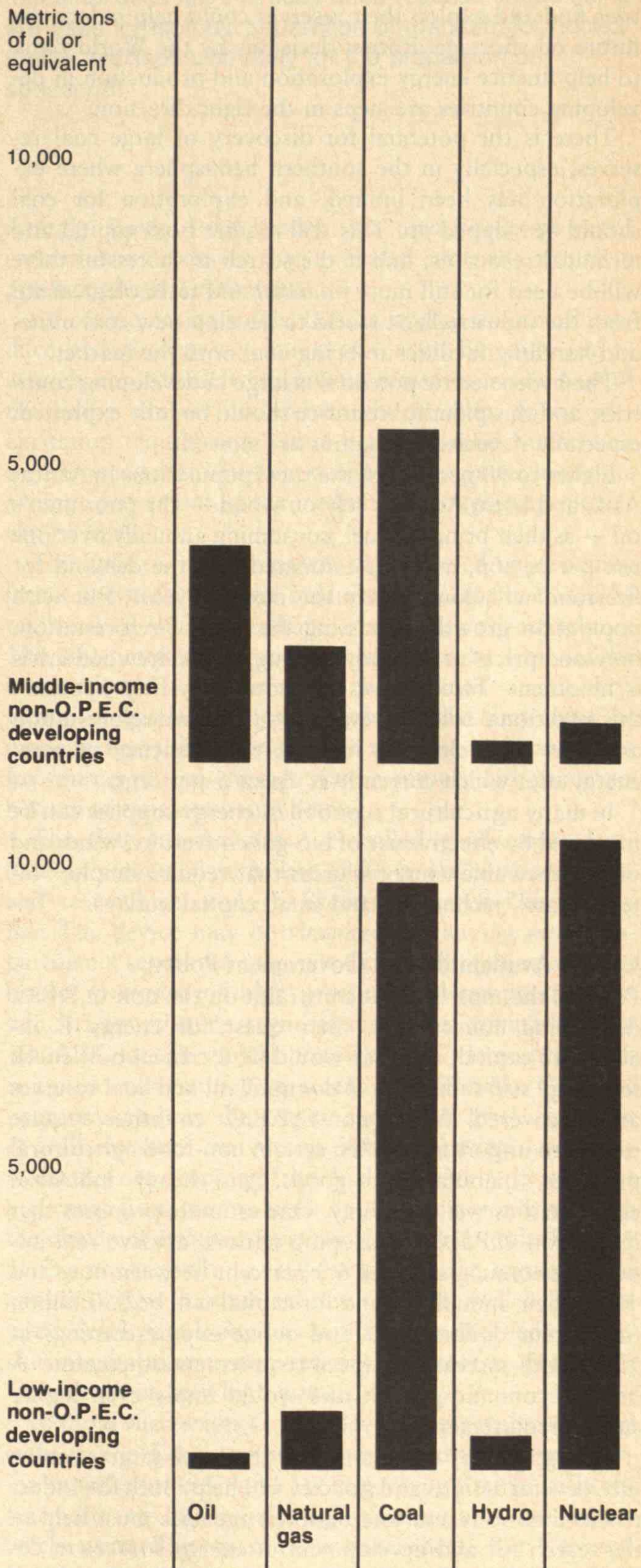
As described earlier, certain developing countries could produce substantial amounts of coal and gas. Indeed, as a group, the non-O.P.E.C. developing countries will be self-sufficient in terms of coal and gas and in fact may be modest exporters in both 1985 and 2000. But production of these resources will also be concentrated in a few countries, leaving many in the position of needing imports.

The result of such an imbalance in supply and demand could be a "bidding" war, with the "well-to-do" industrialized nations severely constraining the plans and aspirations of many non-O.P.E.C. developing countries. Clearly many pressures of the last five years on the "have-not" nations will continue and intensify during at least the rest of this century, and the next 20 years could see significant economic and political instability. What can be done to reduce the potential for dangerous instability in this situation?

One important response has already come out of our increasing understanding of the growing energy interdependence between the developing and developed nations. A conclusion of the Conference on International Economic Cooperation in June, 1977, which remains to be tested by international cooperation is that "during occasional periods of inadequate energy supply, the international community should . . . give priority consideration to the particular vulnerability of developing countries most dependent on oil . . . to satisfy their essential domestic, industrial, and economic development requirements." How such cooperation could occur in a world as dependent on oil as today's is not easy to imagine. It is imperative that industrial countries curb their appetites for petroleum and stimulate their own oil production. And O.P.E.C. countries should take account of the need for world economic stability in their pricing and production strategies.

The member countries of the International Energy Agency — an official industrialized-country energy forum — have recently taken a major step forward by agreeing to limit their combined oil imports in 1985 to a level of 26 million barrels a day, only 13 per cent above that of today. This implies serious (and in some cases severe) conservation measures and increasingly rapid development of domestic energy sources. Whether or not the goal is

Energy resources in the non-O.P.E.C. developing countries. Though reserves are far from fully explored, it's clear that many non-O.P.E.C. developing countries have substantial resources awaiting exploitation. Technological and financial aid from developed countries may be vital if these reserves are to be exploited and the potential for international tension and conflict reduced.



reached depends largely on the success of the United States in reducing oil imports to 6 to 8 million barrels a day in 1985.

As we have pointed out, oil exploration has been limited in most non-O.P.E.C. developing countries, and estimates of reserves are correspondingly poor. Investments from the industrialized countries — in the form of both financing and technology — to help the developing countries find and exploit their reserves could help reduce the future oil shortage. Recent decisions by the World Bank to help finance energy exploration and production in developing countries are steps in the right direction.

There is the potential for discovery of large coal reserves, especially in the southern hemisphere where exploration has been limited, and exploration for coal should be stepped up. This will require both capital and technical resources; and if the search is successful there will be need for still more financial and technological aid from the industrialized world to develop new coal mines and handling facilities to bring coal onto the market.

The hydroelectric potential is large in developing countries, and this plentiful resource should be fully exploited, especially if nuclear programs are slowed.

Eighty to 90 per cent of the rural populations in Africa, Asia, and Latin America rely on wood — the poor man's oil — as their principal fuel, consuming annually over one ton per person, and it is estimated that the demand for firewood will double over the next 25 years. But with population growth surpassing the rate of reforestation, firewood prices are already soaring, and a firewood crisis is imminent. Two courses of action may help maintain this traditional role of firewood — increased reforestation and new technology to increase the efficiency of rural energy use, which currently is about 5 per cent.

In many agricultural economies, energy supplies can be increased by effective use of bio-gas converters, wind, and other renewable energy sources that require simple, "intermediate" technology and small capital outlays.

Capital Availability and Government Policy

Perhaps the most serious constraint on the non-O.P.E.C. developing countries in their quest for energy is inadequate capital, and this would be a critical bottleneck to energy self-sufficiency if domestic oil and coal reserves are discovered. Many non-O.P.E.C. countries require capital to import foodstuffs, certain non-food agricultural products, manufactured goods, and heavy industrial equipment as well as energy. One estimate proposes that if the non-O.P.E.C. developing nations achieve real annual economic growth of 6.3 per cent between now and 1985, their annual demand for capital will be $50 billion (in current dollars) over and above export earnings in 1985, with increasing capital requirements thereafter. A higher economic growth rate would imply even higher capital requirements.

Though it is by no means clear that such targets can be met, several actions and policies will help. Both the industrialized nations and international agencies must help in the search for and development of energy sources in developing lands. The developing countries, for their part, should encourage joint ventures, explicitly protect foreign commercial investments, and reduce to a minimum red tape and other bureaucratic restrictions. International arrangements are needed to help developing nations stabilize their export earnings, and better means may be needed to control inflation and so protect O.P.E.C. nations from a loss of real purchasing power.

The developing nations may themselves moderate their future energy demands. The traditional approach to development emphasizes rapid growth of an industrial infrastructure based on capital-intensive methods of production, with the agricultural sector stagnated. A more balanced development, with equal investment in industry, agriculture, and services, would be less capital- and energy-intensive, and there is some evidence that some developing nations are moving toward this emphasis.

Even taken all together and with full effect, these steps may not successfully equalize the pressure of future energy demands on all the nations of the world. But given that energy is the key to overall economic growth, we can only hope that tackling the energy problems of non-O.P.E.C. developing countries is not postponed or downgraded. Given the long lead times involved in most energy projects, it is already later than we think.

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High-Power Lasers

Letter, marked, 10

James P. Reilly

Industrial uses have already been realized. In the offing are uses for isotopic separation of uranium, for nuclear fusion, perhaps ultimately for the propulsion of spacecraft.

In the early 1960s, it was postulated and then demonstrated that a pencil-thin beam of concentrated electromagnetic radiation produced by a rather innocuous-looking tube could burn its way through simple materials. Since that time, science and technology have been hard at work making that device — the laser — more powerful, more efficient, and in general more useful to humankind.

Today, even the prospect of laser beams propelling rockets into space appears conceivable, though it is estimated that the scheme would require some hundreds of megawatts, perhaps even gigawatts, of average power. In a more immediate context, high-power continuous-output lasers ranging up to 20 kilowatts are entering factories for metalworking tasks ranging from heat-treating automobile camshafts to ship-welding. Lasers for uranium isotope separation to fuel nuclear power plants and lasers for accomplishing the release of fusion energy are both being investigated. So are laser capabilities for defense applications.

The route to the high average powers and high peak powers required for extended application of the laser was unclear at first. To be sure, all lasers depend on non-equilibrium states in which active molecules of the lasing medium are raised to an "upper laser level" of energy, from which they relax to a "lower laser level," giving up energy in the process. The energy takes the form of photons that compose the laser beams. Waste energy heats the lasing medium, making it more difficult to maintain the upper-level population in the case of a continuously-emitting laser, or to repump (re-excite) the medium in the case of a pulsed laser. For this reason, a cooling mechanism is required.

In the earliest lasers, the waste heat generated in the course of lasing limited the average power of the device's beam to very low amounts. These lasers were excited by diffuse longitudinal electric discharges, and looked to the casual observer like long, large-diameter fluorescent light tubes. The heat produced at the center of a tube laser diffused to the walls of the tube. The rate varied inversely with the radius. The area of active cooling, on the other hand, varied directly with both the radius and the length of the tube. Average power was therefore roughly proportional to length but independent of cross-sectional area, and the only way to high power was to make longer and longer laser tubes, typified by such devices as the U.S. Army's Long John Laser, an electrically-powered carbon-dioxide device that extended some 60 meters to produce about 2,500 watts.

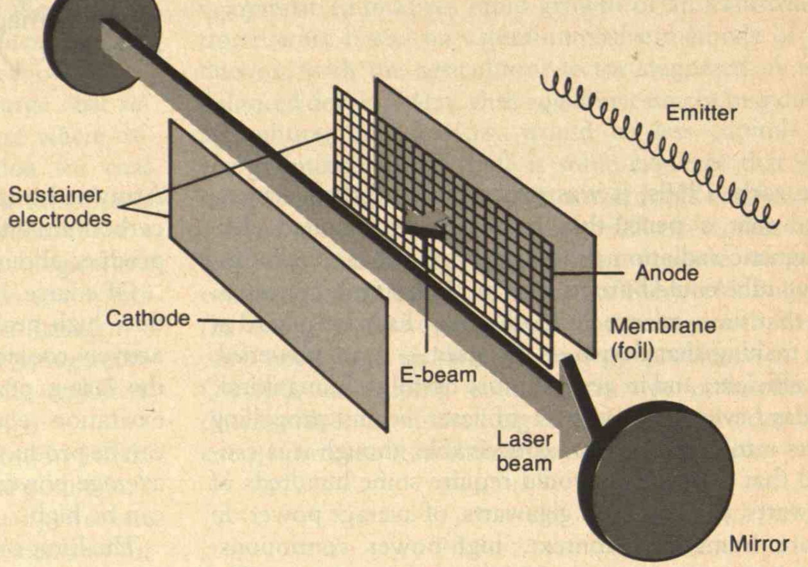
Of course, lasing solids, liquids, and gases can all produce high peak-power bursts of energy. But diffusion to actively cooled side walls must remove the waste heat of the lasing process and return the medium to its pre-excitation (equilibrium) state before another such burst can be produced. This long wait between pulses limits the average power out of the medium, although peak power can be high.

The limit on average power was relieved by designing lasers in which the laser medium flows, for heat can be removed in such a fashion — that is, convectively — 100,000 times more rapidly than it can be removed by conduction in a laser in which the medium is stationary. Liquid or gas lasers, both utilizing media that could be made to flow, therefore became the potential candidates for sources of high average power output, with gas lasers becoming the dominant choice.

The first success was a so-called gasdynamic laser (G.D.L.), invented in the late 1960s by Arthur Kantrowitz and researchers at Avco Everett Research Laboratory, Inc. The device may be visualized as having two compartments separated by a nozzle. The first compartment houses a region of high pressure and temperature, in which a gas mixture stagnates at a typical temperature of 1,400 °K. and a typical pressure of 17 atmospheres. It contains only some 10 per cent of molecules (CO_2, the operative gas) at the upper excitation level, with the overall mixture in an equilibrium state: as many molecules are dropping from high to low energy states as are rising from low to high. As the gas expands through the nozzle, it attains supersonic speed and cools. Because of this cooling, the lower-level population virtually disappears a few centimeters downstream, well before the upper-level population has significantly declined. The result is a population "inversion" sufficient to produce a laser beam of very high power.

In rapid succession, G.D.L. devices were scaled up from eight to 135 kilowatts of laser output over several exciting months in 1967 and 1968, proving dramatically the feasibility of indefinitely high continuous-wave power levels using flow to remove waste heat. But although G.D.L.s retain an important role for certain defense pur-

The ionizer/sustainer concept for a carbon dioxide laser. Here the lasing depends upon the creation of a gas in which free electrons have a high temperature compared to that of ions or atoms. This is accomplished by first partially ionizing the CO_2 with an electron beam that passes from its vacuum housing through a foil membrane to enter the laser. A voltage is applied to complete the excitation in a controlled manner and produce the lasing. The laser beam travels between mirrors at the ends of the lasing chamber; the carbon dioxide flows so as to be cooled outside the chamber.



poses, their invention was most important as a breakthrough to new gas lasers. After all, problems unique to high laser power were met and solved in the development of the G.D.L.; for example, high power requires cooled mirrors that not only do not melt under the laser flux but also retain their surface contour under continuous operation. Moreover, the molecular kinetics and optical arrangements for amplifying photon emission used in the early CO_2 electric discharge tube lasers turned out to be applicable in high-power lasers quite generally once the flow principle was added.

Producing high average power from an electric discharge laser required one other invention beyond the application of flow. Consider that population inversion can be produced when electrons in an ionized gas have a very high temperature compared to the kinetic temperature of ions or molecules. This occurs in what is known as a glow discharge. If, however, the size of the discharge or the pressure of the gas is increased too much, the discharge becomes unstable and an arc forms. Not only the electrons but also the molecules and ions in the gas are heated to high temperatures. This destroys the population inversion.

The difficulty of making large, high-pressure glow discharges was solved for CO_2 and other gas lasers emitting radiation in the infrared spectral region by the invention of the ionizer/sustainer concept, illustrated above. Here the ionization is produced separately from the population inversion, usually by a large-area beam of high-energy electrons. A second power supply — the sustainer — further excites, or "tunes," the electrons produced in the ionization by raising the temperature to a point where 80 to 90 per cent of the total input power goes directly into the CO_2 laser's upper level. The temperature, however, is not so high as to produce self-ionization and consequent arc formation.

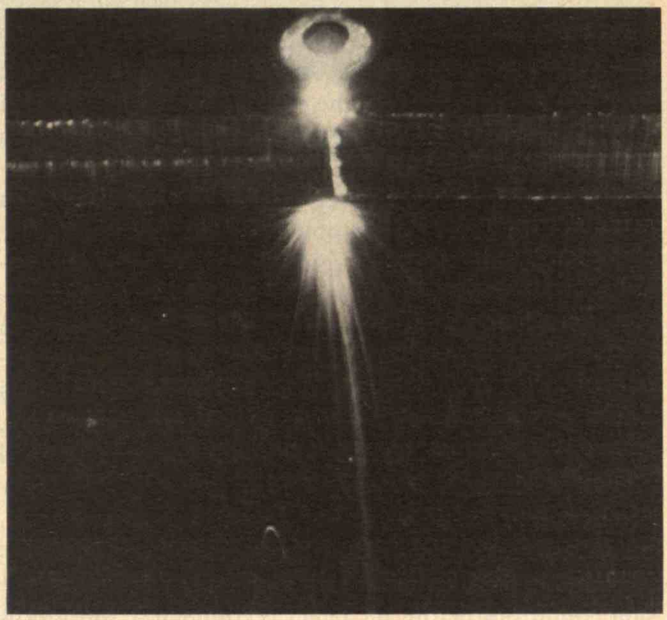
In addition to its superior efficiency, the high-power electric discharge laser offers the advantage of operation with lasing media other than CO_2 (CO, for example) and the capability of delivering various average power outputs from a single device. Moreover, the ability to use subsonic rather than supersonic flow for cooling led to closed-cycle lasers in which gas is excited, lased, cooled and then recirculated back to the laser cavity for reuse.

Industrial Applications

With the obvious additional advantage of running on power from an ordinary electrical outlet, the high-power continuous electric discharge laser, operating at up to 20-kilowatt output, has opened the way to an extraordinary variety of new industrial uses of the laser in the field of metalworking. A single laser can weld, cut, surface harden, and surface alloy.

The *welding* is equivalent in quality to that produced by a conventional electron beam, and without the requirement of operation in a vacuum. The laser beam is focused on a very small spot where two pieces of metal join. In this way it produces very high power densities — for example, more than 10^6 watts per square centimeter. This rapidly melts and displaces the metal, leaving a deep, narrow void or hole commonly referred to as a keyhole, which provides a beam path deep into the material. The molten walls of the metal are supported by the pressure of the metal vapor. At the same time they act as a refocusing

A laser performs a butt-weld in stainless steel: when focused to a spot size of 0.03 inches diameter, it produces power densities of 2,200 kilowatts per square centimeter. The heat generated melts the metal, welding half-inch thick steel at 50 inches per minute. The laser is the Avco HPL, a continuous wave CO_2 device rated at 15 kilowatts; it is the highest power industrial laser now marketed.



mechanism to maintain the required high power density.

As the beam moves along the weld zone, the melt flows around the sides of the keyhole in a thin liquid layer, joining and solidifying behind. A three-quarter inch penetration weld in stainless steel can be performed at a rate of 30 inches per minute using 16 kilowatts of laser power. Since the beam can be directed by mirrors, the laser can process areas that are not easily accessible by conventional methods — welding pipe from the inside, for example.

The use of the laser for *surface hardening* has attracted interest because the process eliminates heating the entire part and is self-quenching with minimal part distortion. In hardening where only the surface of the material need be heated, the beam is focused to a broader spot than for welding. Alternatively, it can be scanned rapidly as in a television raster to form a rectilinear spot of any size on the workpiece. The surface to be hardened is coated with an energy absorber such as colloidal graphite. When the beam passes over it, heat is conducted into the metal, which remains below the melting temperature but reaches the critical temperature for hardening to occur. Rapid quenching is caused by conduction of heat to the cold interior of the metal. This creates a hard layer to the desired depth without significantly disturbing the surface. Both surface temperature and penetration depth can be controlled by automatic adjustment of beam size, speed, and power. The beam's large depth of field allows processing of irregular pieces or parts of different sizes.

As for *surface alloying,* when a thin surface layer is melted, its chemistry can be altered by the addition of alloying material into the molten region. Significant cost savings over conventional methods have been demonstrated using the technique on valves and valve seats, for example, with processing times of only 1.5 seconds per valve and alloy material cost of only two to three cents, compared with some 25 to 50 cents per valve for alloys now in use.

The automotive industry both in the U.S. and in Europe has been active in finding new applications for the marvelous flexibility and agility of the laser. Uses have also been identified in the shipbuilding, construction, farm machinery, and aerospace industries.

Laser-Induced Fusion

High laser power as a viable industrial tool has been a relatively easy derivative from the development of the ionizer/sustainer electric discharge gas laser. Other applications both for high average power and for pulses of high peak power have proven more taxing to the art of laser development. One such spur to recent efforts arises from the attempt to develop a method for laser-induced thermonuclear fusion for electric power generation.

Thermonuclear fusion occurs in the stars. On earth it occurs in nuclear explosions. The specific fusion rate is linearly proportional to the density of the fuel and nonlinearly proportional to the temperature of the fuel. Therefore the amount of energy released at a fixed high temperature is proportional to the density of the fuel multiplied by its confinement time.

In the more conventional scheme for a fusion power reactor, the objective is to achieve sufficiently long confinement times for a hot, gaseous fuel by the use of electromagnetic fields. A more recent approach employs lasers to produce very hot, very high-density plasmas (ionized gases) whose confinement time is limited by the inherent inertia of matter.

One approach revolves around the pellet-implosion concept. Pioneered by KMS Industries and the subject of large programs at both Los Alamos Scientific Laboratory and Lawrence Livermore Laboratory, the concept requires laser irradiation of tiny spherical glass pellets filled with deuterium and tritium to produce the conditions at which fusion will occur. The deuterium-tritium fuel must be compressed to a density of some 1,000 grams per cubic centimeter at a temperature of 30 to 40 million °K. Laser technology is still far from producing the pulses that would be needed to heat the fuel directly. Instead, the goal is to direct at a pellet from all sides simultaneously a number of pulses of less than a nanosecond (a billionth of a second) in duration. This would implode the pellet: its surface would be heated to 5 to 100 million °K. in a few nanoseconds, causing hydrogen to boil off at thousands of miles per second. The escaping gas would behave like a

A scheme to use a laser to propel a spacecraft. The beam produced by the laser is directed upward toward the rear of the craft, where it vaporizes a "fuel" — even water, perhaps. The supersonic jet created by this vaporization lifts the craft.

rocket, reacting against the pellet surface on all sides to squeeze the vaporized deuterium-tritium mixture to a density some 10^2 to 10^4 times greater than lead — higher, in fact, than the density in the center of the sun. Energy in the form of neutron fluxes from the resulting fusion would be absorbed in liquid lithium surrounding the reactor chamber and removed via heat exchangers to power a conventional steam-driven power plant.

The two types of lasers which most nearly meet the requirements for a laser fusion system are the CO_2 gas electric discharge laser and the neodymium glass laser. Both are being developed to explore the viability of laser fusion; both lack key qualities at present. Their deficiencies have led to experimentation with corrective techniques, and also to a search for what laser scientists have dubbed the "Brand X" laser — a device that would intrinsically meet all the criteria for laser-induced fusion.

One criterion is that the laser beams must produce pulse widths in the nanosecond range, so as to create fusion conditions before the pellet is completely vaporized. High-energy lasers of this class are currently under construction in several laboratories, most notably Lawrence Livermore Laboratory in California.

High-power solid lasers such as the neodymium glass laser operate in much the same way as high-power pulsed gas lasers do, but with a slight difference. Here the input energy to the laser is not allowed to produce laser action until the arrival of a laser pulse of relatively low energy. This is accomplished by what is termed a M.O.P.A. (master oscillator/power amplifier) chain, within which the pulse from the laser, or oscillator, is directed into a string of amplifiers, each of which adds energy to the pulse. The amplifiers usually have successively larger apertures to enable the lasing material to accomodate the increasing energy; for in glass lasers, the surface of the solid lasing rod can withstand only a limited amount of energy (in joules) or power (in watts) per square centimeter before fracturing. The limit for neodymium glass is 10 to 100 joules per square centimeter, depending on pulse duration. The limitation in the case of a lasing gas is somewhat different: the medium can undergo electric breakdown (arcing) at high laser flux levels. High-power gas lasers can withstand some 10^9 watts per square centimeter for long pulses and many hundreds of joules per square centimeter for short pulses.

The glass laser under development at Lawrence Livermore for the fusion program is designed to deliver 10 kilojoules in about a nanosecond. The present efficiency of glass lasers is restricted, however, to 0.1 per cent, and it is doubtful that improved pumping techniques can raise it much beyond a few per cent further. In addition, a successful fusion reactor will require repetitive pulsing of the lasers, presenting a serious drawback to the use of the glass laser in view of the limitation that conductive cooling of waste heat places on such devices, as described earlier. This limitation becomes progressively more formidable as the laser is scaled to increasingly higher power. (The CO_2 laser, though capable of multi-kilojoule output with no restrictions on repetitive pulsing, suffers a drop in efficiency when operating in the nanosecond pulse range.)

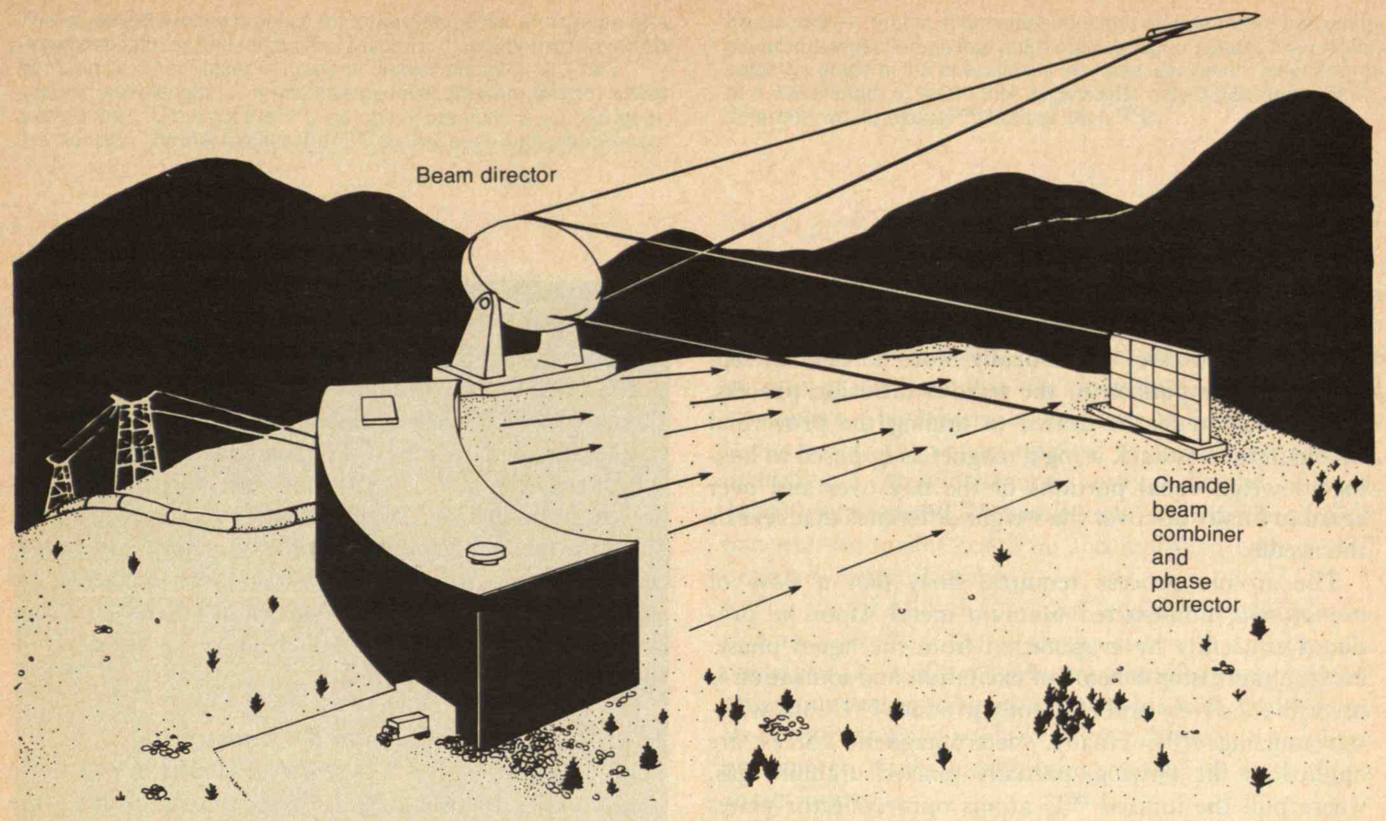
Another problem is one of wavelength, and concerns the way the laser energy will couple with the pellet. In particular, the extremely fast heating required to achieve the necessary high density in the pellet is confounded if long-wavelength photons, which have less energy, begin to interact with vapor at the periphery of the cloud formed around the pellet in the initial stage of heating. Photons will be absorbed, and heating of the peripheral low-density vapor will result. This will generate an energy-absorbing plasma far from the pellet, and thus will decrease the energy delivered to the pellet itself. Ongoing experimentation with pellet design currently indicates that optimum wavelengths may be shorter than the 10-micron wavelength of the CO^2 gas laser and the 1.06-micron wavelength of the glass laser.

New methods of frequency doubling and tripling (corresponding to wavelength halving or thirding) may mitigate the deficiencies with new lasing systems, both gas and solid-state. However, the economics of commercial power systems, probably necessitating many simultaneous laser pulses in the 10 to 100 kilojoule class — this in addition to the other criteria — will in all probability call for a new class of laser. The rare gases argon, krypton, and xenon, used in lasers emitting radiation in the ultraviolet range, are being explored as possible "Brand X" candidates for the pellet-implosion concept.

Magnetic Confinement for Fusion

A second potential use of lasers for fusion is a magnetic confinement approach that not only takes advantage of the relatively long wavelengths of pulsed gas lasers emitting in the infrared but can also directly use their typical 3 to 30 microsecond pulse-widths. The lasers involved include CO_2 lasers (10.6 microns), CO lasers (4.5 microns), and a class of high-power gas lasers under increasingly intense development in recent years. These latter are the chemical lasers, which operate in the low infrared at about 2.7 to 3.8 microns.

The chemical laser is so designated because the lasing molecules, generally either hydrogen fluoride (HF) or deuterium fluoride (DF), first come into being when the medium reaches an excited state. The lasers are therefore said, somewhat inaccurately, to be chemically pumped



(or excited) as opposed to the thermal excitation of gas discharge lasers or the electrical pumping of electric discharge lasers.

The nature of the pumping is as follows: Fluorine and hydrogen gas and a diluent (usually helium) are used in the laser. Either the F_2 or the H_2 (D_2 in the case of the DF laser) is dissociated electrically, thermally, or by photon bombardment. The product atoms are then mixed with the other reactant to form HF or DF, which thus is "born" in an inverted state. Lasing and mixing must be simultaneous because of the rapid de-excitation of the molecules.

Applied in the magnetic confinement fusion concept, the infrared chemical lasers make it possible with a pulse of laser energy to generate a plasma column in a long, small-diameter, gas-filled tube. The plasma is confined from radially expanding by a strong magnetic field. Neutrons generated in the plasma escape through the magnetic field, to be absorbed in lithium and converted to power in much the same manner as in the pellet-implosion concept. Typical tube lengths are hundreds of meters, and typical plasma column diameters are a few millimeters.

The potential electrical efficiency of the chemical laser — that is, the light energy emitted per unit of electrical energy input — is nearly 100 per cent, which makes it an attractive prospect for use in the magnetic confinement method. At present, though, CO_2 gas laser technology is being applied to the fusion development effort, and long-pulse CO_2 laser efficiencies at the kilojoule level are about 25 per cent. There seems to be no barrier to increasing the efficiency to 30 per cent. A best possible efficiency of approximately 40 per cent is set by the laws of quantum physics.

Laser Isotope Separation

In its natural state, uranium contains 0.7 per cent of the isotope ^{235}U and 99.3 per cent of the isotope ^{238}U. For use in U.S. light water nuclear reactors the fissionable ^{235}U must be increased to 3 per cent, while for nuclear explosives it is typically increased to 90 per cent. To achieve just 3 per cent enrichment, uranium hexafluoride (UF_6) containing the two isotopes must be pumped through a gaseous diffusion cycle over a thousand times, with ^{235}U yielded little by little. In addition to the high capital cost of the plants containing banks upon banks of diffusion barriers, almost half the cost of the process itself is in electricity for the pumping. Clearly, relying on diffusive separation for enrichment, especially on a scale to meet U.S. energy needs in the 1980s and beyond, presents a substantial cost problem.

Laser separation of uranium isotopes offers a solution to the problem. It has been known for many years that the wavelengths of certain spectral lines of uranium are significantly different for the various isotopes of the element. As a matter of fact, these differences were originally used in assaying the isotopic content of uranium. Laser techniques take advantage of the spectral separation between ^{235}U and ^{238}U to isolate the former.

Two basic techniques are under development. The so-called atomic process uses high-power *visible* laser light to selectively ionize the rarer ^{235}U atoms in a monatomic uranium gas. The light is supplied by a high-power tunable wavelength laser, which involves an optically pumped and rapidly moving liquid dye as the laser medium. By contrast, the so-called molecular process uses high-power *infrared* laser light to selectively excite vibrational energies of molecules containing one isotope over molecules containing the other; the process requires

a molecular gas — typically UF_6. It is the selective ability to isolate most of the ^{235}U in a single cycle that makes both these processes dramatically more efficient at separation in comparison to the tedious diffusion process. An analogy might be drawn to finding the proverbial needle in the haystack using a magnet as opposed to having to weigh equal portions of the hay over and over again to finally discover the weight difference that reveals the needle.

The atomic process requires, first, that a flow of monatomic, non-excited uranium metal vapor be produced efficiently by evaporation from the liquid phase. Next, a multi-step scheme of excitation and ionization is used to selectively and efficiently produce ^{235}U ions without ionizing ^{238}U. Finally, electromagnetic forces are applied to the flowing, partially ionized uranium gas. These pull the ionized ^{235}U atoms onto collector plates with only minor effects on the flow of non-ionized uranium.

In early low-density proof-of-principle experiments, conducted in 1971, tuned laser light was provided by either a pair of tuned laser systems or else by a single dye laser. This produced selective excitation, and was followed by light from a pulsed nitrogen laser, which produced ionization. The result was in excess of 50 per cent enrichment of ^{235}U. The process is illustrated schematically by the energy level diagram on page 63, where the laser used for selective excitation of the uranium atoms is called the exciter, and the laser which ionizes the selectively excited atoms is called the ionizer. The wavelengths of the exciter and ionizer are designated λ_E and λ_I, respectively. The ionization process is made highly selective by the use of two separate visible laser frequencies, generated by high-power liquid dye lasers repetitively pulsed to provide high average power at extremely high peak-power levels.

Experiments have also been conducted at higher density, under conditions simulating commercially attractive processes. The experiments demonstrated 6 per cent product enrichment in a single pass, which is adequate for the production of light water reactor fuel.

An important difference between the molecular and atomic approaches is that typical internal energies of molecular vibration are about one hundred times smaller than the energies of atomic ionization, so that relatively low-energy infrared lasers may be used for excitation, provided the molecules occupy lower vibrational energy states. In particular, the lower the initial temperature of the molecules, the greater the fraction of molecules in lower energy states, and the larger the effect of selective energy input in exciting molecules of the gas that contain one isotope of uranium and not the other. Most molecular separation processes rely on supersonic expansion to cool the gases.

Once the gas is preferentially excited, molecular separation will require irradation by a second laser, causing the excited molecules to dissociate (break apart). Alternatively, it will require a selective chemical reaction in which only the laser-excited molecules participate. A research group at Los Alamos Scientific Laboratory is pursuing the former technique (photodissociation). In scaling up the process to a point where large quantities of uranium can be enriched, however, a crucial challenge will be the development of high-power tunable wavelength lasers in the infrared.

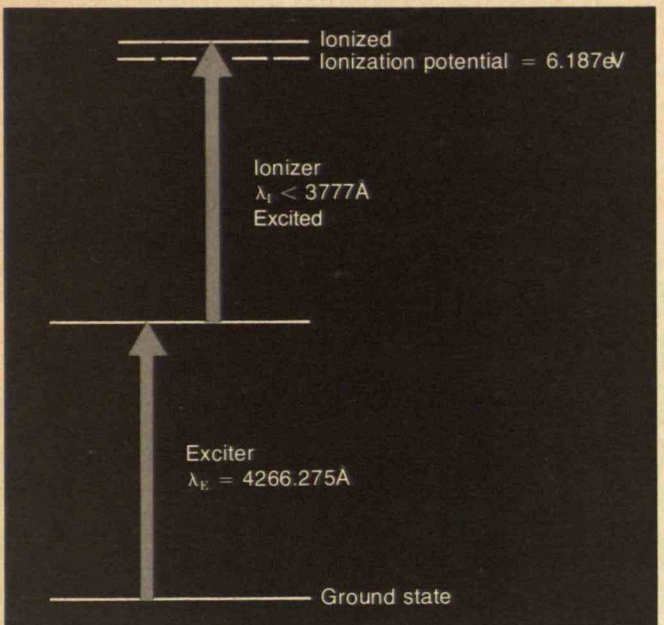
Laser Beam Transmission in the Atmosphere

High-power lasers can deliver power density at a distance which varies (in vacuum) with the square root of the power and with the diameter of the final mirror used to concentrate the energy. Therefore, the possibility of high-power lasers being important in weapons, radars, illuminators, rangers, and long-range designators has been a principal reason for their development, and techniques of beam handling, though by no means limited to these applications, have been crucial throughout. Beam handling at high power is generally split into two areas: the optical elements at the transmitter, and the beam propagation path from transmitter to target or receiver.

Optical elements in laser devices and their pointing systems use reflecting surfaces (mirrors) rather than transmitting solids such as lenses. In order to preserve the quality of the high-power beam, these focusing and beam-directing mirror surfaces must retain their "figure," or surface contour, to better than one-fourth of a laser wavelength. This means that machining and polishing tolerances in the range of 0.0003 inches are required of the basic mirror, with retention of these tolerances under laser flux levels of 10 kilowatts per square centimeter, considerably higher than peak heating rates at the very tip of an I.C.B.M. reentry vehicle. Therefore, optical elements in high average-power applications must be highly reflecting and also must be uniformly cooled. It is a triumph of mechanical engineering, metallurgy, and optical polishing and coating technology that such mirrors exist today.

The laser beam-path is also a consideration. More specifically, the wavelengths of the infrared gas lasers dominant today are in a region at which atmospheric gases such as water vapor and carbon dioxide absorb energy. Depending on the laser wavelength and the concentrations of these absorbers, power losses can range from 3 to 30 per cent per kilometer of beam path. The effect on the beam is often very serious.

The so-called atomic process for separating ^{235}U, an isotope of uranium useful as fuel for nuclear reactors. Two steps are involved. First, an "exciter" laser is tuned to deliver photons of a very specific wavelength (λ_E in the energy-level diagram shown) which excites the ^{235}U but not the ^{238}U isotope of uranium. A second laser, the "ionizer," further excites the ^{235}U so that each such atom loses an electron — that is, it becomes ionized, and therefore subject to electromagnetic forces that pull it onto collector plates. The critical, selective stage of the operation is the initial excitation: laser energy at a wavelength of 4,266.324 Ångströms, only 0.058 Ångströms different, would excite ^{238}U rather than ^{235}U.



Because of this absorption, the air in the beam-path heats very slightly and can act as a gaseous lens, concentrating the beam or alternatively spreading it. Beam spreading, called "thermal blooming," is particularly problematic in the use of high-energy lasers over the long, multi-kilometer paths characteristic of strategic and tactical laser defense applications. Then, too, atmospheric dust particles under very high laser flux levels initiate plasmas which can cause energy losses. Water droplets in clouds and rain shatter under pulsed irradiation, while fog droplets detonate. Yet when the droplets are "burned out" by a pulsed laser beam, propagation appears to be as good as through standard air. Moreover, the increasingly active field of adaptive optics is of particular interest in the handling of such problems. Computer systems can now sense the aberrations introduced into the laser beam by a hot laser mirror, laser windows, and the atmospheric beam-path, and can introduce, in real time, compensating phase differences to minimize or even remove the beam aberrations.

The ability of the laser to heat material at a distance is the basis for the idea of laser propulsion, in which rapid vaporization (as in the case of the fusion-pellet irradiation described earlier in this article) produces in a given material a supersonic jet whose exhaust velocity propels a spacecraft. Since the vaporization energy could be added to the propellant by a laser on the ground, the propellant need not supply any chemical energy in itself. Even water could be used. An illustration of the concept is shown on page 61.

Such a system might work as follows: A pneumatic tube similar to those used to fire torpedoes would be used to lift the vehicle off the ground. A few hundred meters up, the laser beam would take over, propelling the vehicle in only a few minutes of operation some thousand kilometers. The vehicle, by this time at its maximum velocity, would then coast upward to any orbital altitude, including a geosynchronous orbital height of some 36,000 kilometers. The small kick of energy needed for injection into orbit could be accomplished with a small onboard chemical rocket.

The payoff of such a system would be extraordinary. Calculations show that a single laser with an output of one gigawatt (1,000 megawatts) would be capable of orbiting tonnage equivalent to the payloads of 2,000 Saturn Vs every year. Each payload put in orbit would weigh approximately a ton, with an initial (launched) mass of only about four tons.

The laser, or course, presents an engineering challenge of fair dimension. But scaling up lasers to the high powers needed for realization of a laser propulsion system is an extrapolation from present laser capabilities that has no known theoretical impediment.

The concept, then, is an exciting one: the ability to launch and supply a continuous stream of small, inexpensive vehicles using cheap propellants could be used to support engineering activities in orbit on a huge scale compared to what is presently foreseeable with conventional rocket propulsion devices. It is possible, given the prospect of such a system, to envision the laser's ultimate contribution to the solution of our energy problems as providing the means for constructing orbiting power stations to harness the energy of the sun.

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James P. Reilly received his B.A.E. in aeronautical engineering from the University of Detroit, two master's degrees (in aeronautics and astronautics and in mechanical engineering) from M.I.T., and his Sc.D., again from M.I.T., in gas dynamics. He is now Vice President of Science and Engineering at W. J. Schafer Associates, Inc. Previously, he was Vice President of Applied Technology at the Avco Everett Research Laboratory. Dr. Reilly is the inventor of the basic ionizer/sustainer electric discharge concept, which is presently implemented in all electron-beam sustainer electric discharge lasers. He has extensive experience in the experimental and theoretical aspects of high-power, repetitively pulsed, electrically excited N_2/CO_2 lasers.

Heat Pumps: Off and Running . . . Again

Heat pumps appear to defy the law of energy conservation by producing thermal output two to three times greater than their mechanical input. But public unfamiliarity and the poor performance of some early models hamper their acceptance.

Leon R. Glicksman

Letter, marked copy, + 10 extra copies to author.

Fully half of the energy used in the residential and commercial sectors of the U.S. economy goes for space heating: one-sixth of total U.S. energy use, and one-fourth of our total oil and natural gas consumption. The sheer size of this energy demand establishes residential and commercial space heating as a fertile field for new or improved technologies that may increase the efficiency of energy use. The inefficiency of current space conditioning apparatus adds incentive to the effort.

Some Efficient Space Heating Alternatives

Several existing technologies can substantially reduce the amount of oil and gas consumed in space heating: solar heating, district heating systems using heat supplied from power plants, and co-generation plants, which supply heat and electricity to local areas. Some of these technologies already compete economically with conventional oil and gas heating in certain applications. But unfortunately, each of these three practices have limitations and drawbacks.

Although fuel costs have risen dramatically, the total cost of solar collector systems (including installation, operation, maintenance, and replacement) make the economics of today's systems, at best, marginally competitive with that of conventional fossil fuel heating systems *(see "Solar Economics Comes Home," February, 1978)*. Annually, one square foot of well-designed flat plate solar collector can gather thermal energy equivalent to that produced by burning one to two gallons of fuel oil. To provide the energy equivalent to one million barrels of oil per day — about 6 per cent of U.S. consumption — from 7.5 to 15 billion square feet of solar collectors would be needed. At an installed cost of $20 per square foot, a low estimate for today's collector systems, these collectors would cost $150 to $300 billion. In comparison, the annual cost of one million barrels of oil at $13 per barrel is only about $13 million, suggesting a return on the investment in solar collectors that is unacceptably long.

Waste heat from large electrical power plants can, in theory, be used to heat buildings. But the slightly heated water rejected by power plant cooling systems is normally too cool to use for space heating. The temperature of the rejected cooling water can be raised — at the expense of electrical generating capacity — but pipeline delivery of the heated water to users requires a substantial capital investment. For such a system to be feasible, most of the buildings on a pipeline right-of-way must use the system, and customers cannot be further than five to ten miles from the power plant.

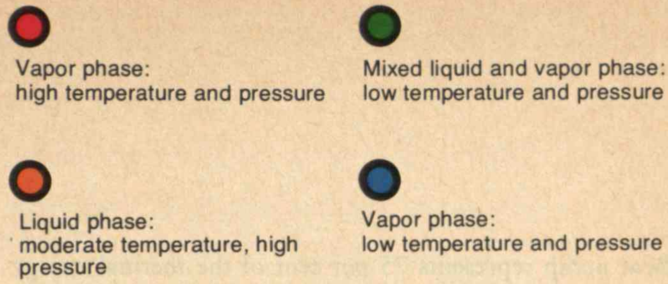
For a smaller power plant, the reclamation and distribution of waste heat can be an effective space heating practice. For example, the heat produced by a diesel engine and absorbed by its coolant can be reclaimed and used to heat a hospital complex or a factory building. While attractive for some specific applications, these systems need redundancy to provide reliable electrical and heating service, may present siting problems, must meet environmental standards, and have uncertain maintenance requirements.

Electrical Heating with Heat Pumps

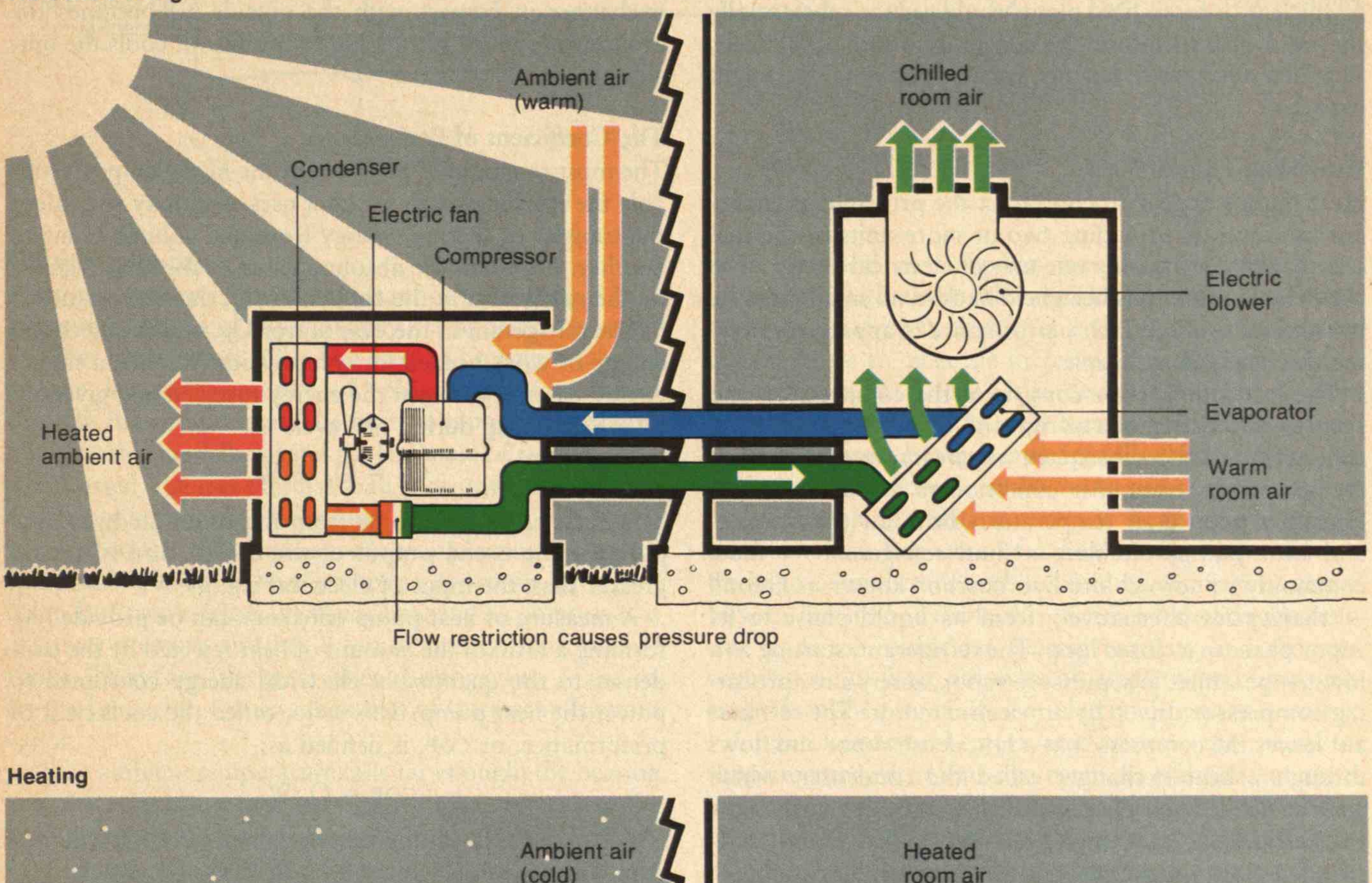
At first glance, heating with electric-resistance devices seems an excellent way of space heating. It's a clean and reliable method; electricity will be available for the foreseeable future, and the installation of electrical-resistance heating devices is relatively simple. Unfortunately, electrical-resistance heating is an inherently inefficient way to utilize the thermal energy consumed at an electrical generation plant. An electrical-resistance device can convert close to 100 per cent of electrical energy to useful thermal output, but the overall efficiency of a nuclear or fossil fuel plant in converting the chemical energy in fuel to thermal energy and then to electrical energy is only 30 to 40 per cent. Therefore, the economics of electrical-resistance heating is attractive only in areas that have inexpensive power generated, for example, by hydroelectric plants.

Electricity can produce space heating far more efficiently when used to power heat pumps. Heat pumps can produce (or extract) more thermal energy for space conditioning — both heating and cooling — than they consume in electrical energy. Commercially available heat pumps typically can produce more than twice as much output in thermal energy as they receive in electrical energy input, and some heat pumps are capable of producing more than three times more thermal output as they receive in electrical input. Combined with an electrical generating and distributing system that is 30 per cent efficient, a heat pump can yield an overall heating efficiency of 75 per cent; that is, the heat produced by the

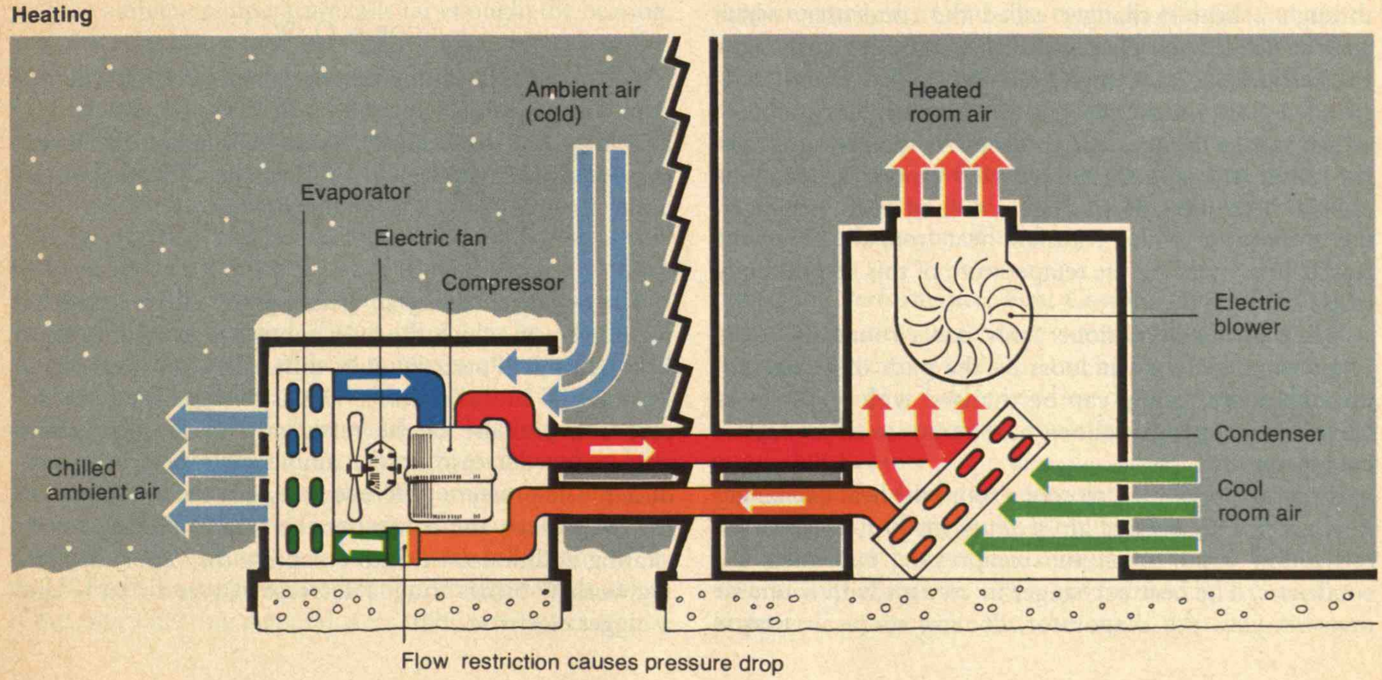
In air conditioning mode, the compressor forces refrigerant toward the heat exchanger that is outdoors *(top)*; in heating mode, the flow circuit is altered so that refrigerant is forced toward the heat exchanger that is indoors *(bottom)*. Note that the compressor itself runs in the same direction in both modes, and that the change of refrigerant flow is accomplished with a system of valves.



Air conditioning



Heating



heat pump represents 75 per cent of the thermal energy consumed by the power plant to generate the electricity. In certain circumstances an electrically powered heat pump can operate with efficiencies greater than 100 per cent. No other system now in use using fossil fuel to produce heat has a higher efficiency.

Because they produce heat with such great overall efficiency, heat pumps powered by electricity generated by nuclear or fossil-fired plants could reduce substantially the need and therefore the consumption of fossil fuels. But their acceptance has not been so rapid as one might expect.

How Heat Pumps Work

Heat pumps appear to contradict the principle of energy conservation by providing two or more units of thermal energy while using only one unit of electrical energy. The use of heat pumps has been held back in no small measure by skepticism about their performance in apparently defying this scientific principle.

The heat pump cycle consists of the compression and consequent heating of a refrigerant, liquefaction of the refrigerant, and the subsequent expansion and cooling of the same refrigerant. Air conditioners use a similar sequence to reduce air temperature. Both air conditioners and heat pumps circulate a fluid refrigerant — most commonly a fluoro-chloro hydrocarbon known as Freon® — that cycles alternatively from its liquid phase to its vapor phase in a closed loop. The refrigerant, starting as a low-temperature, low-pressure vapor, enters a reciprocating compressor driven by an electric motor. The refrigerant leaves the compressor as a hot, dense vapor and flows through a heat exchanger called the condenser, which transfers heat from the refrigerant to a body of air. Now the refrigerant, as a high-pressure, cooled liquid, confronts a flow restriction — a valve or capillary tube — which causes the pressure to drop. As the pressure falls, the refrigerant expands and partially vaporizes, becoming chilled. It then passes through a second heat exchanger, the evaporator, which transfers heat from the air to the refrigerant, reducing the temperature of this second body of air.

While an air conditioner only cools room air — its evaporator is always indoors — the path of refrigerant through a heat pump can be changed with a system of valves. This capability allows heat pumps to either heat or cool room air.

As noted previously, to cool a room the heat exchanger in contact with outside air receives the hot, compressed refrigerant vapor from the compressor, becoming the condenser. The heat exchanger in contact with room air then becomes the evaporator, cooling room air that is blown through it, and also dehumidifying room air by condensing water vapor on its fins and routing the collected liquid water out of the room.

To heat air, the compressor pumps refrigerant toward the heat exchanger in contact with room air. This heat exchanger, which was the evaporator in air conditioning mode, thus becomes the condenser in heating mode. Room air blown through it becomes warmed. The heat exchanger in contact with the outside air becomes the evaporator; as the refrigerant evaporates it cools the outside air.

The Coefficient of Performance

The most remarkable property of the heat pump is probably the efficiency with which it uses electricity to achieve the transfer of thermal energy from one volume of air to another. If we call the absolute value of the heat rejected by the refrigerant in the condenser Q_c, the heat absorbed by the refrigerant in the evaporator Q_E, and the electrical energy or work needed for compression W, then a simple energy balance between the energy received and given up by a heat pump during one cycle is:

$$Q_C = Q_E + W.$$

The heat transferred to or from the room air by a heat pump is the useful output of the device, and is always greater than the input of electrical energy W.

A measure of heat pump efficiency can be provided by forming a ratio of the amount of heat rejected by the condenser to the quantity of electrical energy consumed to power the heat pump. This ratio, called the coefficient of performance, or COP, is defined as:

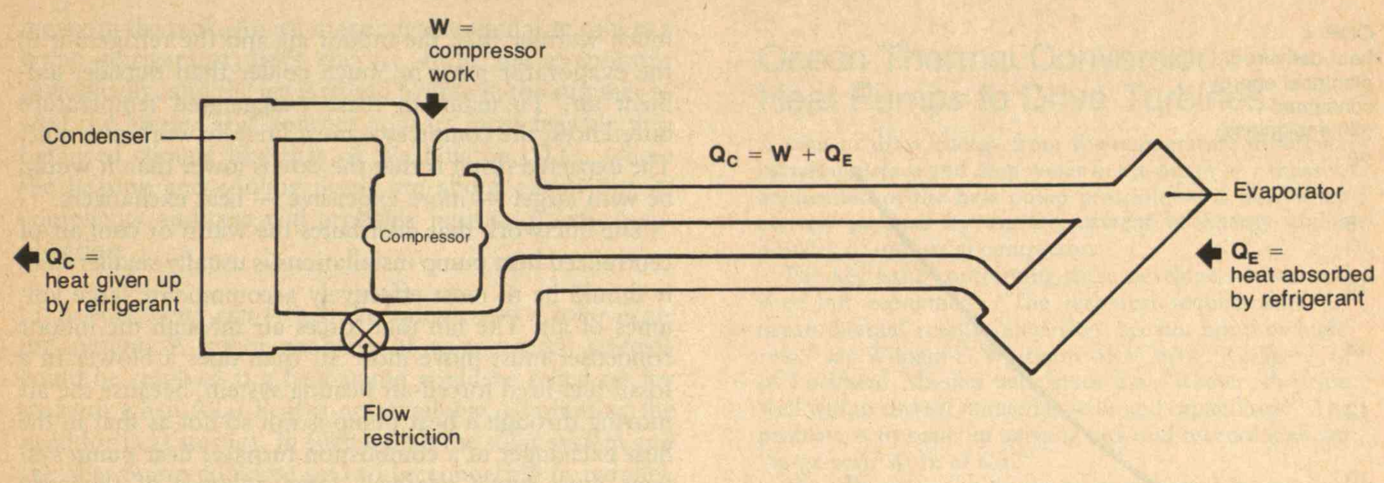
$$\text{COP} = Q_c/W.$$

The COP depends on the minimum and maximum refrigerant temperatures experienced in the cycle, where T_{low} and T_{high} are, respectively, these two temperatures expressed in degrees Kelvin or Rankine. The theoretical upper limit of the COP can be expressed as

$$\text{COP}_{lim} = (1 - T_{low}/T_{high})^{-1}.$$

The actual efficiency of a heat pump is dependent on the climate in which the heat pump is operated. A given heat pump will perform quite differently, for example, in Boston and in Tallahassee. This is because the temperature and pressure of the refrigerant in the heat pump evaporator decrease as the ambient temperature is reduced. The pressure difference between the refrigerant in the evaporator and condenser therefore increases, necessitating additional work to compress the vapor. Increasing work W brings about a decrease in overall COP — and a bigger electricity bill.

Under certain conditions a heat pump can put out more thermal energy (Q_C) than it consumes in electrical energy (W). But the law of energy conservation has not been even remotely challenged — additional input of thermal energy via the evaporator accounts for the difference (Q_E).



Heating Capacity

Heating capacity is more important in evaluating a heat pump than COP, and unfortunately it also decreases as the ambient temperature falls. The drop in capacity is caused by the lessening amount of refrigerant mass moved through the compressor. The heating capacity is proportional to this mass flow rate: the less mass of refrigerant is compressed, the less thermal load it can transfer through the heat pump cycle. The volume flow rate of refrigerant vapor through the single-speed reciprocating or rotary compressors used in heat pumps is approximately constant. But cold refrigerant vapor entering a compressor is at lower pressure and has a lower density than warmer vapor. Therefore, the mass of cold refrigerant — and its thermal capacity — is less than that of warmer refrigerant vapor.

If the ambient temperature falls far enough, the heating capacity of a heat pump may be insufficient to meet the heating demands of a building. At this point an auxiliary heat source is needed. Customarily, electrical resistance coils are used for such supplemental heat, but extensive use of resistance heat signifiantly boosts total work W, thereby lowering the seasonally-averaged COP.

Some electrical utilities that now experience their peak demand in the summer are encouraging the use of heat pumps — with electrical auxiliary heat — to increase winter electrical demand. But caution is to be exercised: electrical consumption of heat pumps peaks sharply during low ambient temperatures. The combined effects of a sudden drop in COP when auxiliary heating coils are called into operation, the increasing heat demand at low ambient temperatures, and the concomitant decrease in operating efficiency produce a large winter peak load. For example, when the ambient temperature falls from 45° F to 25° F, the heating requirement approximately doubles. If the entire heating demand were to be met by resistance heat, electrical consumption would also double. But a heat pump with electrical resistance auxiliary heat would experience a drop in COP from 2 to 1.3, *tripling* electrical consumption to meet the increased heating demand.

Normal practice today is to design heat pump systems with enough capacity to meet summer cooling needs and to let the winter heating capacity fall where it may. This procedure is acceptable in the South or other areas where air conditioning demand exceeds heating demand. It minimizes the first cost of a heat-pump-air-conditioner package — important both to building contractors and to buyers. But in the North, this summer-based design practice leads to insufficient heating capacity and the consequent use of large amounts of supplemental heat, generally furnished by inefficient electrical-resistance coils.

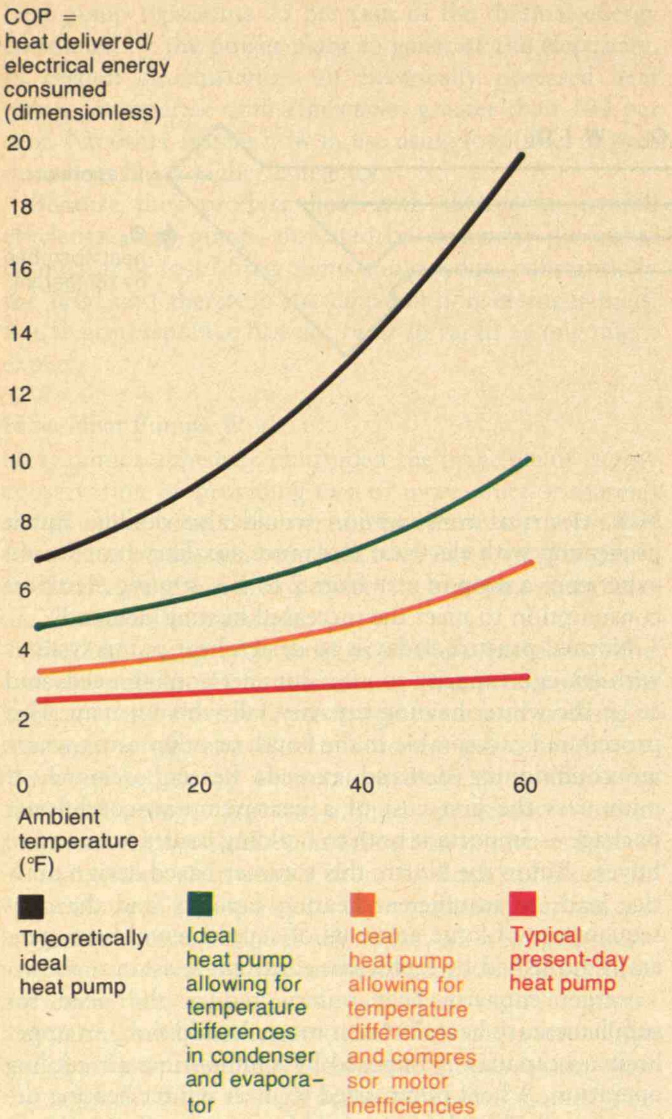
Larger capacity heat pumps reduce the need for supplementary heat, but cost more. In addition, an upper limit on capacity is imposed by summertime air cooling operation. A heat pump sized to meet winter heating demands in the North is oversized for summer air conditioning requirements. The result is poor comfort control: the large heat pump operates in air conditioning mode for only short bursts of time, and during those bursts delivers an excessive amount of cold air.

Improving Performance: First Cost vs. Operating Costs

Heat pumps were introduced commercially in the 1950s; consumer interest was high, and at one time in that decade there were 43 different brands on the market. But almost without exception these machines proved to be unreliable because their designers used air conditioner components without fully considering the more intensive demands that a heat pump would make.

Heat pumps have regained attention in the 1970s, and several manufacturers are now marketing substantially improved equipment. But the wide disparity between

Heat pumps with average COPs of 3.0 or greater will use less energy overall than fossil fuel furnaces. Today's units come close to this efficiency under some conditions.



ideal heat pump performance and the actual performance of today's equipment leaves much room for improvement. Some of the present performance shortfall originates in the emphasis on minimizing manufacturing costs and consumer prices. For example, heat exchangers — condensers and evaporators — are made relatively small to keep costs down. But small heat exchangers have limited capacity to transfer heat between refrigerant and air. To achieve a high rate of heat transfer with a small heat exchanger requires a rather large temperature difference between the refrigerant and the air. This means that, in heating mode, the refrigerant in the condenser must be much warmer than the indoor air and the refrigerant in the evaporator must be much colder than outside, ambient air. To maintain these exaggerated temperature differences, the compressor must literally work overtime. The expected result is that the COP is lower than it would be with larger — more expensive — heat exchangers.

The ductwork that distributes the warm or cool air of centralized heat pump installations is usually smaller than it should be to most effectively accommodate large volumes of air. The fan that forces air through the indoor condenser must move more air than does a blower in a fossil-fuel-fired forced-air heating system, because the air moving through a heat pump is not so hot as that in the heat exchanger of a combustion furnace; heat pump systems must move relatively large volumes of modestly warm air. Large ductwork facilitates the job of the circulation fan by reducing back pressure, permitting more air to move through the system with the same blower effort. But contractors have long-accepted standards for erecting ductwork; in addition, larger ductwork requires more volume which may not be available in some building designs.

A Selection of Advanced Concepts

A number of ideas have been proposed to improve the performance of heat pumps, but the costs of these systems are uncertain. Unfortunately, proponents tend to be overly optimistic about their particular system — several of the more complex advanced concepts are claimed to have first costs equal to that of a simple heat pump without sacrificing system reliability or longevity! Although the following descriptions of several advanced concepts sound promising, final evaluation must await actual performance and cost data.

□ *A volume of water can be used to store and provide low-temperature heat.* Heat pump COP and heating capacity will be increased if the evaporator receives thermal energy from a warm body of water instead of from ambient air. However, a large quantity of water is needed to provide enough thermal energy for an entire heating season. A heat pump serving an average size home in the Midwest will reduce the temperature of one acre-foot of water 20° F over the heating season. As the evaporator coils rob heat from an undersized tank of water, the water may reach its freezing temperature. Ice will then form on the evaporator, impeding further heat transfer and rendering the heat pump ineffective.

□ *This ice is deliberately used in a so-called "annual cycle energy system."* In the winter heating mode, a heat pump evaporator draws heat from a tank of water, form-

ing ice in the tank. An ice-maker device similar to that in a home refrigerator frees the ice from the evaporator periodically, and the ice is stored for use in the summer to cool the house. This concept appears most feasible in a balanced climate like that of Washington, D.C., where the heating and cooling needs are about equal; but its complexity and cost will probably limit its practical application.

☐ *A heat pump can be used to supplement a solar heating system.* A major problem of solar energy systems could be resolved if a heat pump could be relied on for warmth when solar heat is not available, eliminating the need for heat storage. In such a plan the solar system and the heat pump could be said to be connected in parallel, the collector supplying heat directly to the interior of the house and the heat pump, deriving heat from outdoor air, supplementing it as needed. The costs and operating characteristics of such a parallel system can be estimated from what is known about each component operating alone. At the present time, such a parallel system suffers in comparison with a standard air-to-air heat pump with electrical auxiliary heat because of the high capital cost of a solar collector system. Furthermore, widespread adoption of such a parallel system would result in a sharp peak of demand for electric energy on cold, sunless days. If utility rates should change to reflect the cost of the standby capacity needed to meet such a peak load, operating costs of the parallel heat-pump-solar-collector system could increase substantially.

☐ *A solar collector system can be connected in series with a heat pump.* If the heat pump and solar collectors are connected in series, the collectors can be used as the heat source for the heat pump evaporator on sunny days, enhancing heat pump performance. However, experience has shown that a fairly large collector array and an associated heat storage system are needed to satisfy the thermal needs of a heat pump. Such a system has been shown to require the same amount of electricity annually as would be needed for the more flexible system in which a heat pump and solar collector are used in parallel.

☐ *A thermal storage system combined with a heat pump can alleviate the problem of oversize heat pumps for cooling in northern climates.* Recall that the summer-winter capacity balance point is typically set by air conditioning requirements, resulting in heat pumps too small for heating duties in the North. An oversized heat pump, capable of handling northern heating demands, will provide short periods of high-capacity air conditioning interspersed with long shutdown periods. A modest-sized cold storage

Ocean Thermal Conversion: Heat Pumps to Drive Turbines

A plan to draw energy from the temperature difference between surface and deep water in the ocean — a massive application of the heat pump principle — is now being actively pursued by the Department of Energy and a number of industrial contractors.

The key issue confronting these developers is not science but economics. "The technical requirements [of ocean thermal energy conversion] are not novel or high-risk," say William F. Whitmore and Carl E. Rudiger, Jr., of Lockheed Missiles and Space Co. "Rather, they are well within current industrial skills and capabilities." The problem is to scale up existing arts and technologies for "large-scale work at sea."

The Department of Energy plans exactly that course of development, in three stages:

☐ In 1979 a one-megawatt ocean thermal plant will be built on a mining barge and tested in tropical waters. The plant will circulate its ammonia refrigerant through the 40° F temperature difference between surface and deep ocean water to create pressure and turn a turbine.

☐ In 1982 two ship-mounted 5 to 25-megawatt plants will go to sea. One is to generate electrical energy for a power system grid; the other, to use its electrical output for the production of ammonia.

☐ In 1984 a commercial generating demonstration plant combining several 5 to 25-megawatt modules totalling 100 megawatts will be launched.

This large-scale application of the heat pump principle has the same advantage as the smaller ones described in the accompanying article. An ocean thermal energy conversion plant, "using a renewable, uncontrollable resource without delivery costs requires only 700 non-renewable calories input for 1,000 calories out," say Messrs. Whitmore and Rudiger. They insist that there is nothing novel in needed technology. The use of ammonia as a working fluid necessitates fabricating the heat-exchanger of aluminum and titanium, and both are "well known in the aerospace community," they told the 1978 annual meeting of the American Institute of Aeronautics and Astronautics last winter. High-speed machining techniques for these and other materials have been developed for the Polaris missile program. The required platforms will be quite like those for offshore oil development, as will the undersea hardware.

Perhaps the biggest problem, think the Lockheed engineers, will be to overcome the "distrust of novel approaches and techniques in the public utilities industry." Indeed, in pursuing its own interests in ocean thermal energy conversion work, Lockheed has had to do some of the utilities' work for them: developing cost figures, envisioning marketing projects and "even proposals for capital formation."

But Messrs. Whitmore and Rudiger are confident: "Our cost studies show that the energy from ocean thermal energy conversion, even in the first generation of production plants, would be competitive with oil at $14/ barrel," they told the A.I.A.A. — *J.M.* ☐

"buffer" between larger capacity heat pumps and the building will permit the system to provide continuous cooling. A somewhat larger thermal storage facility could be used to hold the hot or cold output of the heat pump produced during off-peak hours. Heating efficiency could be maximized by charging the heat storage during the warmest periods of the day; cooling efficiency, by charging the thermal storage facility with cold temperatures during the coolest periods of night. Studies show, however, that peak electricity rates must be substantially greater than off-peak rates before a large thermal storage system becomes worthwhile to the consumer.

□ *Capacity control — a means of varying the pumping rate — can be used to "throttle down" large heat pumps when full capacity is too great for heating or cooling needs.* Such capacity control can be achieved by three means: using a variable-speed electric motor to run the compressor; using two different sizes of compressors to provide, in combination, three possible flow rates; and varying the charge of refrigerant pumped by each compressor stroke. By such means, a heat pump can be "sized" according to demand to provide, for example, high capacity in heating mode during low ambient temperatures and low capacity in heating mode during more moderate weather. The ability to vary the capacity of a heat pump would help consumers minimize electrical input, provide a better balance between the lengths of compressor "on" and "off" cycles, and permit the use of heat pump systems of potentially large capacity to meet occasional, abnormal heating and cooling demands.

□ *Natural gas-fired heat pumps operate with great efficiency.* A gas-operated heat pump consists of a heat pump driven by an engine fueled with gas rather than by an electric motor. The gas engine itself may operate with relatively low efficiency, but it rejects considerable heat, which can be used as needed to supplement the heat delivered by the heat pump. A typical efficiency is 25 per cent, which means that 75 per cent of the energy in the fuel may be recoverable through the engine cooling system and in exhaust gases. If we can recover 70 per cent of this waste heat to provide useful warmth, the total heat delivered by the gas-powered heat pump may be as much as 1.025 times the natural gas combustion energy — an overall conversion from fuel energy to thermal energy greater than 100 per cent. But the gas-powered heat pump achieves its great efficiency at the expense of increased complexity and higher capital cost. As a result, gas heat pumps are not in widespread use. Given the volatile pricing and less-than-certain supply of natural gas, a simpler, less efficient all-electric heat pump seems to be a more attractive alternative. In fact, it remains to be seen if gas-fired heat pumps can be improved sufficiently to become competitive with conventional gas heat.

The Bottom Line: Capital Costs vs. Operating Costs

While the capabilities required of a heating and cooling system can be calculated in a straightforward manner, the question of costs may be viewed in several ways.

Five or more years ago, consumers and builders considered only the first cost of heating and cooling systems, virtually ignoring operating costs. With the increasing price of energy, operating costs have now become a very important consideration.

Heat pumps represent more capital investment than conventional fossil-fuel heating and cooling systems and much more than electrical space heating systems in locations where central air conditioning is unnecessary. In such situations, heat pumps are economically competitive only when life-cycle cost — operating cost plus capital cost — is considered. But the calculation of life-cycle cost is subject to a number of uncertainties. We cannot be sure about the costs of electricity in the future, or about the cost and reliability of alternative fuels; we cannot predict the rate of interest to be paid on the capital invested in a heat pump or about possible tax credits for energy-efficient systems; we do not know so much as we should about the life of a heat pump system and about maintenance costs.

At today's fuel prices, life-cycle costs of heat pumps are close to but generally higher than those of conventional fossil-fuel heating and cooling systems. If air conditioning is not included with the fossil-fuel system, then a heat pump is even less competitive. However, we know that the price of natural gas — the principal fuel for home heating in the U.S. — is artificially low, as a result of controls imposed on interstate supplies. Should the price of natural gas be decontrolled, or should more expensive synthetic gas come into widespread use, the relative costs and subsequently, the attractiveness, of heat pumps and fossil-fuel heating systems could well change.

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Leon R. Glicksman received his B.S. at M.I.T. in 1959, his M.S. at Stanford in 1960 and his Ph.D. at M.I.T. in 1964. He has been a member of the M.I.T. Mechanical Engineering Department faculty since 1966 serving as an Assistant and Associate Professor and Lecturer. Since 1974 he has also been a member of the M.I.T. Energy Laboratory. He has been awarded the Melville Medal and the Robert T. Knapp Award by the American Society of Mechanical Engineers. His current research interests include end use technology for energy conservation, fluidized bed combustors and cooling towers.

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